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Predictors of Mathematics Majors at the Post-Secondary Level of Education

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at the Post-Secondary Level of Education

by

Megan L. Reineke
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A dissertation submitted to the Education Faculty of Lindenwood University
in partial fulfillment of the requirements for the
degree of

Doctor of Education

School of Education

Declaration of Originality

I do hereby declare and attest to the fact that this is an original study based solely upon my own scholarly work here at Lindenwood University and that I have not submitted it for any other college or university course or degree here or elsewhere.

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A Dissertation

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Dr. Lynda Leavitt, Chairperson — Date: 3/4/2011

Dr. William Emrick, Committee Member — Date: 3/4/2011

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Abstract

While there are numerous studies examining the courses students take at the secondary level and how different levels of mathematics courses can affect student achievement in beginning post-secondary mathematics courses, there are no studies that examine math majors at the post-secondary level of education. In addition, many reports stating gender and ethnicity gaps in the field of mathematics fail to discuss the issue surrounding what type of student pursues a mathematics degree. Understanding mathematics majors, including the types of high schools they attended and their ethnicities, may provide some insight into which students are becoming interested in the area of mathematics during their high school experience. This study will explain the predictors that correlate to a student's choice of majoring in mathematics at the post-secondary level of education as well as provide readers with information regarding how predictors, such as the type of high school and a student's background, can affect his or her decision to major in the area of mathematics.

Using the National Education Longitudinal Study of 1988 and Education Longitudinal Study of 2002 data sets, frequency analysis determined various significant differences when addressing the possibility of differences in the proportion of students pursuing the area of mathematics when compared by the high school sector they attended and when further disaggregated according to their genders and ethnicities. A logistic regression analysis was conducted to examine the value of significant independent variables as meaningful predictors of the likelihood of a student pursuing mathematics.

While a greater proportion of non-public high school students chose to major in mathematics than public sector students, according to the NELS: 88 data set, there was no

difference found between the public and private sectors in the ELS: 2002 data set. Similarly, according to the NELS: 88 data set, when compared to public sector males, a greater proportion of non-public high school males majored in mathematics, while no significant differences existed between females of the various school sectors. However, within the ELS: 2002 data set the opposite results occurred, indicating a significant difference in public and private sector females majoring in mathematics but no difference between the various sector males.

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Chapter One-Introduction

Background and Purpose of the Study

The area of mathematics has been at the center of educational debate for many decades. There are constant reminders from lawmakers that the area of mathematics education within the United States needs improvement since American students' scores are inferior to other nations' scores (Monastersky, 2004). Researchers emphasize the idea that in order for the country to stay competitive, teachers must find ways to interest students in the area of mathematics (Tyson, Lee, Borman, & Hanson, 2007). While there are numerous studies examining the courses students take at the secondary level and how different levels of mathematics courses can affect student achievement in beginning post-secondary mathematics courses, there are no studies that attempt to answer the question about who math majors are at the post-secondary level of education. In addition, many reports stating gender and ethnicity gaps in the field of mathematics fail to discuss the issue surrounding what type of student pursues a mathematics degree. Understanding who mathematics majors are, including the types of high schools they attended and their ethnicities, may provide some insight into which students are becoming interested in the area of mathematics during their high school experience and which groups educators need to focus their attention.

This study will explain the predictors that correlate to a student's choice of majoring in mathematics at the post-secondary level of education as well as provide readers with information regarding how predictors such as the type of high school and a student's background can affect his or her decision to major in the area of mathematics. The three types of high schools that will be used in the separation of the findings will be public, Catholic, and other private. Private schools with religious affiliations other than Catholicism or nonsectarian private schools will be included within the other private high school category. This study will also attempt to disaggregate findings by specific genders and ethnicities in order to determine if the public, Catholic, or independent-private high school sector is highly correlated to specific genders' and ethnicities' decision to pursue the area of mathematics.

There are numerous studies examining the various levels of mathematics courses studied at the secondary level and how such courses can affect student achievement in beginning post-secondary mathematics courses. In addition, there are many reports stating the existence of gender and ethnicity gaps in the field of mathematics. However, there are no studies that examine the type of students who become math majors at the post-secondary level. Understanding who mathematics majors are including the types of high school they attended and their ethnicities may provide some insight into which students are becoming interested in these areas during their high school experience and which groups of students educators need to focus more attention on in order to increase their participation in the area of mathematics. The results of this study can help in the development of secondary and post-secondary programs that increase student interest in mathematics in groups that are not well represented in the field of mathematics.

Statement of the Problem

The following questions addressed in this study are:

1. Are there significant differences between the proportions of students pursuing the area of mathematics when compared by the type of high school they attended, namely public, Catholic, or other independent private?

2. Are there significant differences between the proportions of students pursuing the area of mathematics when compared by type of high school they attended and when further separated, according to gender and ethnicity?
3. Are there predictors of mathematics majors in post-secondary education?

After extensive review of the literature, it was hypothesized that there would be significant differences between the proportions of students pursuing the area of mathematics when compared by the type of high school they attended, namely public, Catholic, or other private. In addition, there will be significant differences between the proportions of students pursuing the area of mathematics when compared by the type of high school they attended and when further separated according to gender and ethnicity. In addition, it was hypothesized that there would be several significant predictors of mathematics majors in post-secondary education.

Using data from the National Educational Longitudinal Study of 1988 (NELS: 88) as well as data from the Educational Longitudinal Study of 2002 (ELS: 2002), the previous hypotheses were tested. Data analysis determined, at two separate time points, 1988 and 2002, if there were significant differences between the proportions of students who majored in mathematics at the post-secondary level when compared by the type of high school the students attended, namely public, Catholic, or other private. In addition, further analysis determined if differences exist when further disaggregated according to gender and ethnicity. In order to determine whether there are potential predictors of students who eventually major in the area of mathematics at the post-secondary level of education, further analysis on the data sets determined if such factors exist. Variables beyond high school sector, gender, and ethnicity were included within this study for analysis purposes. Table 1 and Table 2 include a complete list of variables analyzed from both data sets.

Table 1

Object Codes for National Education Longitudinal Study of 1988 (NELS: 88)

Object Code	Description
SEX	Student's Gender as Reported in Base Year
RACE	Student's Race as Reported in Base Year
BYFCOMP	Student's Family Composition as Reported in Base Year
BYS34B	Student's Mother's Highest Level of Education as Reported in Base Year
BYS34A	Student's Father's Highest Level of Education as Reported in Base Year
BYS4OCC	Student's Mother/Female Guardian's Occupation as Reported in Base Year
BYS7OCC	Student's Father/Male Guardian's Occupation as Reported in Base Year
BYFAMINC	Student's Yearly Family Income as Reported in Base Year
BYSESQ	Student's Socio-Economic Status Quartile as Reported in Base Year
BYS45	How Far in School the Student Thinks He or She Will Get as Reported in Base Year
BYS52	Student's Predicted Occupation at Age 30 as Reported in Base Year
BY2XMSTD	Student's Math Test Standardized Score as Reported in Base Year
BY2XMQ	Student's Mathematics Quartile as Reported in Base Year
BY2XMPP1	Student's Mathematics Proficiency Probability at Level 1 in Base Year
BY2XMPP2	Student's Mathematics Proficiency Probability at Level 2 in Base Year
BY2XMPP3	Student's Mathematics Proficiency Probability at Level 3 in Base Year
BY2XMPP4	Student's Mathematics Proficiency Probability at Level 4 in Base Year
BY2XMPP5	Student's Mathematics Proficiency Probability at Level 5 in Base Year
G8CTRL	Student's School Sector as Reported in Base Year
G8URBAN	Student's School Urbanicity as Reported in Base Year
G8REGON	Geographic Region of Student's School as Reported in Base Year
BYRATIO	Student's School Student-Teacher Ratio in Base Year
F1S49	How Far in School the Student Thinks He or She Will Get as Reported in First Follow-Up
F1S53B	Student's Predicted Occupation at Age 30 as Reported in First Follow-Up
F12XMSTD	Student's Math Test Standardized Score as Reported in First Follow-Up
F12XMQ	Student's Mathematics Quartile as Reported in First Follow-Up
F12XMPP1	Student's Mathematics Proficiency Probability at Level 1 in First Follow-Up
F12XMPP2	Student's Mathematics Proficiency Probability at Level 2 in First Follow-Up
F12XMPP3	Student's Mathematics Proficiency Probability at Level 3 in First Follow-Up
F12XMPP4	Student's Mathematics Proficiency Probability at Level 4 in First Follow-Up
F12XMPP5	Student's Mathematics Proficiency Probability at Level 5 in First Follow-Up
G10CTRL1	Student's School Sector as Reported in First Follow-Up
F1S18B	Student's is Sure He or She will Pursue Further Education After High School in First Follow-Up
F2S43	How Far in School the Student Thinks He or She Will Get as Reported in Second Follow-Up
F2S62	Student's Field of Study Most Likely to Pursue Upon Entering Post-secondary School as Reported in Second Follow-Up
F2S64B	Student's Predicted Occupation at Age 30 as Reported in Second Follow-Up
F22XMSTD	Student's Math Test Standardized Score as Reported in Second Follow-Up
F22XMQ	Student's Mathematics Quartile as Reported in Second Follow-Up
F22XMPP1	Student's Mathematics Proficiency Probability at Level 1 in Second Follow-Up
F22XMPP2	Student's Mathematics Proficiency Probability at Level 2 in Second Follow-Up
F22XMPP3	Student's Mathematics Proficiency Probability at Level 3 in Second Follow-Up
F22XMPP4	Student's Mathematics Proficiency Probability at Level 4 in Second Follow-Up
F22XMPP5	Student's Mathematics Proficiency Probability at Level 5 in Second Follow-Up
G12CTRL1	Student's School Sector as Reported in Second Follow-Up
F2RHMA_C	Student's Units in Mathematics as of Second Follow-Up
F3PSEATN	Student's Highest Level of Education Attained as of Third Follow-Up
PSELASTY	Student's Sector of Last Post-secondary Institution as of Third Follow-Up
PSELASMJ	Student's Post-secondary Major at Last Institution as of Third Follow-Up
F4EDGR1	Student's First Degree/Certificate Earned as of Fourth Follow-Up
F4ESCT1	Student's School Sector for First Degree-granting Institution as of Fourth Follow-Up
F4EMJ1D	Student's Major/Field for First Degree as of Fourth Follow-Up
F4EDGR2	Student's Second Degree/Certificate Earned as of Fourth Follow-Up
F4ESCT2	Student's School Sector for Second Degree-granting Institution as of Fourth Follow-Up
F4EMJ2D	Student's Major/Field for Second Degree as of Fourth Follow-Up
F4HHDG	Student's Highest Level of Education Attained as of Fourth Follow-Up
F4TYPEDG	Student's Type of Post-secondary Degree(s) Attained as of Fourth Follow-Up

Note. From National Center for Education Statistics (NCES) (n.d)

Table 2

Object Codes for Education Longitudinal Study of 2002 (ELS: 2002)

Object Code	Description
BYSEX	Student's Gender as Reported in Base Year
BYRACE	Student's Race as Reported in Base Year
BYFCOMP	Student's Family Composition as Reported in Base Year
BYGNSTAT	Student's Generational Status as Reported in Base Year
BYMOTHED	Student's Mother's Highest Level of Education as Reported in Base Year
BYFATHED	Student's Father's Highest Level of Education as Reported in Base Year
BYOCCUM	Student's Mother/Female Guardian's Occupation as Reported in Base Year
BYOCCUF	Student's Father/Male Guardian's Occupation as Reported in Base Year
BYINCOME	Student's Total Family Income From All Sources in 2001 as Reported in Base Year
BYSES1QU	Student's Socio-Economic Status Quartile as Reported in Base Year
BYSTEXP	How Far in School the Student Thinks He or She Will Get as Reported in Base Year
BYOCC30	Student's Predicted Occupation at Age 30 as Reported in Base Year
BYTXMSTD	Student's Math Test Standardized Score as Reported in Base Year
BYTXMQU	Student's Mathematics Quartile as Reported in Base Year
BYTX1MPP	Student's Mathematics Proficiency Probability at Level 1 in Base Year
BYTX2MPP	Student's Mathematics Proficiency Probability at Level 2 in Base Year
BYTX3MPP	Student's Mathematics Proficiency Probability at Level 3 in Base Year
BYTX4MPP	Student's Mathematics Proficiency Probability at Level 4 in Base Year
BYTX5MPP	Student's Mathematics Proficiency Probability at Level 5 in Base Year
BYMHDEG	Highest Degree Earned by Student's Math Teacher in Base Year
BYSCRTL	Student's School Sector as Reported in Base Year
BYURBAN	Student's School Urbanicity as Reported in Base Year
BYREGION	Geographic Region of Student's School as Reported in Base Year
BYREGURB	Geographic Region and Urbanicity of Student's School as Reported in Base Year
BYREGCTL	Geographic Region and School Sector of Student's School as Reported in Base Year
F1STEXP	How Far in School the Student Thinks He or She Will Get as Reported in First Follow-Up
F1BYDEX	Student's Change in Bachelor's Degree Expectation from Base Year to First Follow-Up
F1OCC30	Student's Predicted Occupation at Age 30 as Reported in First Follow-Up
F1TXMSTD	Student's Math Test Standardized Score as Reported in First Follow-Up
F1TXMQU	Student's Mathematics Quartile as Reported in First Follow-Up
F1TX1MPP	Student's Mathematics Proficiency Probability at Level 1 in First Follow-Up
F1TX2MPP	Student's Mathematics Proficiency Probability at Level 2 in First Follow-Up
F1TX3MPP	Student's Mathematics Proficiency Probability at Level 3 in First Follow-Up
F1TX4MPP	Student's Mathematics Proficiency Probability at Level 4 in First Follow-Up
F1TX5MPP	Student's Mathematics Proficiency Probability at Level 5 in First Follow-Up
F1HIMATH	Student's Highest Math Course of a Half Year or More in First Follow-Up
F1CTLPTN	Student's School Sector Attendance Pattern in First Follow-Up
F1PSEPLN	Student's Post-secondary Plans Right After High School in First Follow-Up
F2EDLEVL	Student's Highest Level of Education Attempted as of Second Follow-Up
F2PS1SEC	Student's Sector of First Post-secondary Institution as of Second Follow-Up
F2MJR2_P	Student's Post-secondary Major in 2006 as of Second Follow-Up
F2STEXP	How Far in School the Student Thinks He or She Will Get as Reported in Second Follow-Up
F2F1EDEX	Student's Change in Bachelor's Degree Expectation from First Follow-Up to Second Follow-Up
F2OCC30P	Student's Predicted Occupation at Age 30 as Reported in Second Follow-Up
F1RMAT_P	Student's Units in Mathematics on High School Transcript
F1RGPP2	Student's GPA for All Courses Taken in the 9^{th}-12^{th} Grades on High School Transcript
F2B15	Student's Field of Study Most Likely to Pursue Upon Entering Post-secondary School as Reported in Second Follow-Up
F2B22	Student had a Major Declared/Undeclared as of the Second Follow-Up

Note. From National Center for Education Statistics (NCES) (n.d)

Limitations of the Study

As a result of using national data sets collected and reported by the United States Department of Education, the results of this study should be able to be generalized to students within the United States. Even with national data from two different time points, there are considerations of several limitations. For instance, the data sets include various schools from different school sectors, which increase the generalizability, but the researcher will examine limitations. Schools from different sectors will have obvious differences but schools within the same sectors could be different from one another because of such aspects as school demographics, school resources, school curriculum, and teacher experience. Limitations will also include incomplete portions of the data sets, the small proportion of students who pursued mathematics at the post-secondary level, as well as factors beyond scope of study including student disabilities. In addition, the ELS: 2002 follow-up studies are not complete at the time of this study so the researcher must use the students' current majors at the post-secondary level versus their completed majors available in the NELS: 88 data set that has been completed prior to this study.

Definition of Terms

The explanations of several terms, continually used throughout this study, are as follows:

National Education Longitudinal Study of 1988 (NELS: 88): "The third major study in the National Center for Education Statistics program of longitudinal studies about the achievement and characteristics of elementary and secondary school students" (McLaughlin & Cohen, 1997, abstract).

Education Longitudinal Study of 2002 (ELS: 2002): "The most recent secondary school longitudinal survey conducted by the National Center for Educational Statistics (NCES), track the educational and developmental experiences of a nationally representative sample of students in public and private high schools in the United States" (Bozick & Lauff, 2007, p. 1).

No Child Left Behind Act (NCLB): "Legislation originating in 2001 requiring individual states to provide a framework for school districts to measure success in promoting and maintaining progress in student achievement" (Wisdom, 2008, p. 17).

Post-secondary Education: Often used to define education levels beyond high school, the term will strictly represent two-year and four-year universities or colleges in this study.

Summary

This study will investigate the proportions of students who pursue the area of mathematics when compared by various factors including the high school sector they attended, including public, Catholic, or independent-private, as well as their gender and ethnicity. The researcher will conduct investigation into the usefulness of various variables in the prediction of mathematics majors. In addition to closing the gap in the current literature, the results of this study can eventually help in the development of programs at both the secondary and post-secondary schools that increase student interest in mathematics in underrepresented groups in the field of mathematics.

The review of literature in the next chapter discusses a brief version of mathematics education history and addresses debates as well as opposing viewpoints of areas surrounding the field of mathematics.

Chapter Two-Review of the Literature

The review of literature explores a brief version of mathematics education history, as defined by major milestones and changes within the area, and addresses debates as well as opposing viewpoints of areas surrounding the field of mathematics at the secondary and post-secondary levels of education. This literature review is meant to give the reader background information needed for the understanding of this study as well as provide a broad view of what is currently known about the area of study. This review of literature will provide brief histories of mathematics education within the public and private sectors, will compare and contrast current debates surrounding the area of mathematics including differences in sector achievement, ability differences between genders, and the possibility of a science and mathematics crisis within the United States. In addition, the literature review will provide background information on the shortage of minorities and women in the field of mathematics.

The History of Public Mathematics Education

Mathematics education in the United States has sustained many changes during its rise and development over the past two centuries. Prior to the mid-18th century, the colonial school system consisted of independent Latin grammar schools that focused primarily on preparing young men in the classical languages for their university studies (Encyclopedia of Children and Childhood in History and Society, 2008). However, in 1749, Benjamin Franklin released *Proposals Relating to the Education of Youth in Pennsylvania*, which would bring about changes in the schools (Parker, 1993). Familiar with the British academies, Franklin described the “academies’ practical curriculum, terminal school nature, commercial relevance, and enlightened coeducation” (Parker, 1993, p. 3). Many of the countries' Latin grammar schools began to broaden their curricula around this time in order to include practical subjects such as mathematics (Encyclopedia of Children and Childhood in History and Society, 2008).

The next influential point in mathematics education came at the end of the 19th century when the United States was changing from a rural agrarian society to an urban industrial society. In 1893, upon the recommendation by the National Education Association's Committee of Ten, the first council formed which included members of both the high school and college communities (Boyer, 1981), the traditional elite high school curriculum spread (Parker, 1993). There was a belief that the subjects taught to those students bound for the university were also appropriate for the majority of students who were destined to enter the workforce upon graduation. In addition, this report by the Committee of Ten recommended a four-year high school curriculum comprised of mathematics as well as other core subjects. However, by 1900, the debate began about whether a set of core courses was in fact appropriate for all students or whether schools should offer alternatives in order to accommodate for student differences. The public school system settled the debate by choosing the more diversified model because the "major objective of the comprehensive public high school curriculum was, and still is, to keep students in school until graduation" (Lee, Chow-Hoy, Burkam, Geverdt, & Smerdon, 1998, p. 316).

With the nation in World War II in the 1940s, the need for school changes once again surfaced. According to a survey conducted by The Research Division of the National Education Association, by December of 1942, 72% of schools reported increasing the emphasis placed on the subject of mathematics during this time of war

(Harap, 1943). Many citizens, concerned about the United States chances of success while at war, objected to the child-centered trend that schools had recently been adopting. In the December 1943 issue of *Educational Leadership*, an article entitled "Discipline as a Skill" described the education system at the time as one that encouraged "dependency, passivity, and conformity" (Fisher, 1943, p. 143) which many believed would fail to teach true discipline to American boys who would soon enter the army life after high school. Claiming that students were no longer receiving the discipline to make them great soldiers, many citizens voiced their desires to return to the 3Rs of education, namely, reading, writing, and arithmetic (Fisher, 1943). The war encouraged educators and the public to recognize the need for more mathematical and technical skills in order to succeed (Herrera & Owens, 2001).

In the late 1950s, the United States once again found itself in a national crisis and the adequacy of the mathematical knowledge of American students became the focus. In 1957, the Soviet Union successfully launched the first satellite into space and with this achievement came concern in the United States that the American mathematics curriculum was inadequate for the emerging technology (Herrera & Owens, 2001). This launch of the satellite "Sputnik" marked the beginning of the New Math revolution (Herrera & Owens, 2001). Large funds became available from the National Science Foundation and the 1958 National Defense of Education Act in order to help with this rising concern (Parker, 1993). These federal funds supported the creation of new curricula revisions to mathematics as well as other sciences such as biology and chemistry (Parker, 1993). Based on the conceptual learning idea founded by psychologist Jerome S. Bruner who believed "that any subject can be taught to any child at any age if the material is logically organized and sequentially presented" (Parker, 1993, p. 9), schools established new curricula. The School Mathematics Study Group (SMSG) with the support of the National Science Foundation aimed "to develop the concepts of mathematics through the structure of mathematics, not through a disconnected assemblage of manipulative 'tricks'" (Rucker, 1962, p. 370). Although the SMSG proposed the introduction of probability and statistics courses (Rosenbloom, 1962) the New Math curriculum was not "concerned with replacing old subject matter with new subject matter" (Beberman, 1962, p. 375) but, rather to match "sound mathematics and sound pedagogy" (Beberman, 1962, p. 375).

By the 1970s, reports that indicated a decline in aptitude test scores deemed the New Math movement, which began a decade earlier, a failure. In the article entitled "The Silent Curriculum: Its Impact on Teaching the Basics", published in the December 1978 issue of *Educational Leadership*, the author Philip Hosford described the problem facing schools after the New Math movement of the 1950s. Hosford (1978) stated that achievement test scores had been falling for 14 consecutive years and that the declines in scores were "greater at successively higher-grade level beginning with grade five" (Hosford, 1978, p. 211). Determined to increase scores, the Back-to-Basics movement began. Gone were the curricula that focused on "sets, logic, and algebraic structures" (Herrera & Owens, 2001, p. 87) and in their place were math curricula that emphasized "computation and algebraic manipulation" (Herrera & Owens, 2001, p. 87).

As the Back-to-Basics movement continued throughout the 1970s, concerns grew during the later portion of the decade. Members of the mathematics education community questioned the dominant place of computation in the elementary curriculum as well as the low priority given to the area of problem solving at all grade levels (Herrera & Owens, 2001). "Dissatisfaction deepened as areas in the field of mathematics gained importance in a changing society but were not reflected in the school mathematics program" (Herrera & Owens, 2001, p. 88). This dissatisfaction would only increase as released results from the Second International Mathematics Study (SIMS) became public. The SIMS surveyed and compared some 40 countries on several aspects of mathematics achievement and curricula (Hanna & Sidoli, 2002) and despite the recent focus on the basics, the performance of the students from the United States had either stayed the same or declined on the basic skills when compared to the First International Mathematics Study taken 16 years earlier (Herrera & Owens, 2001). On 36 items that were given on both the first and second international studies to the eighth-graders tested, the United States students had improved slightly in algebra and measurement in the 1982 study compared to the 1964 results (Willoughby, 1986). However, the United States students' scores had decreased in areas such as arithmetic, geometry, and statistics (Willoughby, 1986). According to SIMS, United States students at the 12th-grade level were below the median of all precalculus topics covered whereas the students were usually near the median on calculus topics (Willoughby, 1986). Willoughby stated that the most important comparison drawn from SIMS was

> children in the United States are not exposed to nearly as much mathematics in their first nine years of schooling as children commonly are in other developed countries, and they learn less. Also, there seems to be some evidence that U.S. children spend less time learning mathematics than do students in other developed

> countries and that mathematics (perhaps all of education) is taken less seriously here than elsewhere. (Willoughby, 1986, p. 85)

The dissatisfaction with the Back-to-Basics movement combined with weak results on several international aptitude tests led to yet another sense of national crisis in the 1980s. This time the call for change was due to concern for the United States' economy (Schoenfeld, 2002). Concerns about the adequacy of the mathematics curriculum became the focus as Japan's economy and test scores outshone the United States' (Schoenfeld, 2002). In April of 1983, the National Commission for Excellence in Education (NCEE) published *A Nation at Risk: The Imperative for Educational Reform* and although a 32-page report; it was printed in numerous magazines and newspapers (Parker, 1993). The publication stated that America was at risk and in decline because the education system was proving to be only mediocre compared to other rising nations (Parker, 1993). When it was reported, "that about 13 percent of 17-year-olds were functionally illiterate, SAT scores were dropping, and students needed an increased array of remedial courses in college" (Department of Education, 2008, p. 1), the nation feared such trends not only threatened students' opportunities but the nation's future as a whole. The National Commission that released this report was comprised of university presidents, scientists, educators, as well as policymakers. Refusing to sugarcoat the deteriorating quality of education in America, they described how the United States, as a nation, had become satisfied with leading the world's education for so long and "lost sight of the basic purposes of schooling, and of the high expectations and disciplined effort needed to attain them" (Department of Education, 2008, p. 2). The report affirmed and updated the suggestions by the Committee of Ten by recommending that high school graduates have three years of the sciences among other core subjects such as English and social studies (Parker, 1993). The Commission also recommended changes in five areas including "curriculum content, standards and expectations of students, time devoted to education, teacher quality, and educational leadership and the financial support of education" (Department of Education, 2008, p. 3).

Shortly after the release of *A Nation at Risk*, the National Council of Teachers of Mathematics (NCTM) responded with the 1989 document *Curriculum and Evaluation Standards for School Mathematics* (Herrera & Owens, 2001). A group composed of mathematics educators including all levels from elementary teachers to college professors, researchers, educational supervisors at the state and district level, as well as people with experience in such areas as technology and teacher education were all consulted in order to produce the *Standards* document (Herrera & Owens, 2001). Unlike previous reports written about mathematics education issues, the *Standards* did not focus on strictly mathematical content but rather considered the necessary ideas one must possess to be mathematically literate at that time in society (Schoenfeld, 2002). At a time when calculators and computers were in extensive use for the calculation of mathematical procedures and when the field saw rapid growth as well as application, the *Standards* advocated for a reform in both content and pedagogy. The *Standards* advocated for "a focus at all grade levels on problem solving, reasoning, connections (between mathematical topics and to real world applications), and the communication of mathematical ideas in written and oral form" (Schoenfeld, 2002, p. 15). The *Standards* document reconceptualized the goals of mathematics education and emphasized mathematics content and instruction appropriate for all students, not just for those students preparing to attend college in the future (Herrera & Owens, 2001).

Two additional volumes of the NCTM *Standards* document produced in 1991 and 1995 focused on the teaching and assessment of mathematical concepts and started a national standards movement just before the released results of the Trends in International Mathematics and Science Study (TIMSS) that took place in 1995 (Schoenfeld, 2002). TIMSS was the third international comparison achievement test and followed SIMS by 15 years. Conducted in more than 40 countries and at the third, fourth, seventh, and eighth grades as well as at the final year of secondary school, students were tested in the areas of mathematics and science (TIMSS & PIRLS International Study Center, 2009). Students, teachers, and principals also reported information about the teaching and learning of the two subjects within the individual classrooms. In addition, the study "investigated the mathematics and science curricula of the participating countries through an analysis of curriculum guides, textbooks, and other curricular materials" (TIMSS & PIRLS International Study Center, 2009, para. 3). Upon the release of results of the study, one of the most important conclusions reported, "was that mathematics in the middle grades in most countries introduced topics in algebra and geometry" (Schmidt, 2004, p. 10). However, the United States students in eighth grade "were mostly studying such arithmetic topics as fractions, decimals, percentages, and ratios, with very little coverage of algebra and virtually no coverage of geometry topics" (Schmidt, 2004, p. 10). This report of less demanding programs was what many parents, teachers, and mathematicians believed would happen when the spread of NCTM-based curricula began just years earlier (Loveless & Coughlan, 2004).

To examine further in-depth, the TIMSS video study, conducted in 1999, examined teaching practices in eighth-grade mathematics classes in the United States as well as six countries, found to have higher achievement levels on the original TIMSS 1995 report. The comparative countries included "Australia, the Czech Republic, Hong Kong SAR, Japan, the Netherlands, and Switzerland" (Hiebert, Stigler, Jacobs, Givven, Garnier, Smith, Hollingsworth, Manaster, Wearne, & Gallimore, 2005, p. 114). Nationally representative samples, chosen from eighth-grade mathematics classrooms in each of the seven nations that participated in the study, had a single recorded classroom lesson for further examination (Hiebert et al., 2005). A research team graded each lesson according to a variety of aspects including the structure and organization of the lesson, presentation of the topic, student practice of the concepts during the class period, as well as analyzed any provided supplementary materials (Hiebert et al., 2005). Once the videotapes and materials were analyzed, the study "results revealed a range of systems of teaching across higher-achieving countries that balance[d] attention to challenging content, procedural skill, and conceptual understanding in different ways" (Hiebert et al., 2005, p. 112). On the contrary, the United States eighth-grade mathematics classrooms frequently reviewed unchallenging, procedural concepts and lessons appeared fragmented to the researchers (Hiebert et al., 2005). For instance, on average only 34% of problems presented in each of the United States lessons were applications using the presented concepts (Hiebert et al., 2005). This was a smaller percentage than other nations such as Japan and the Netherlands (Hiebert et al., 2005). Additionally, the United States was the only country in the study that displayed, within the selected lessons, no instances of having students develop mathematical justification or generalize ideas from specific cases presented within class (Hiebert el al., 2005). As previously stated, the researchers also noted the minimal time used in United States classrooms to study new material. The fact that 28% of the lessons from the United States were entirely reviewing past material and 94% of the lessons contained at least one concept that was review for the students, emphasized previous findings (Hiebert et al., 2005). Many of the lessons in the United States also focused on one topic and experienced interruption by outside sources more than lessons viewed from other countries, which consequently made the coherence of concepts difficult to follow (Hiebert et al., 2005). Additionally, survey data from the TIMSS suggested

> U.S. math teachers are less prepared in their subject area than their more successful counterparts abroad: 78 percent of Singaporean students and 89 percent of Flemish Belgian 8th graders have teachers who majored in math, compared with only 41 percent of U.S. 8th graders. (Loveless & Coughlan, 2004, p. 58)

After the release of the results from the 1995 TIMSS and the 1999 TIMSS video study, researchers suggested that, through analyzing the educational systems that displayed more effective styles of teaching, educators in the United States could improve classroom teaching in order to incorporate challenging mathematics and conceptual learning (Schmidt, 2004). Focusing on such suggestions, the United States in the new millennium created many changes based on these previous results from the past international studies. At the turn of the millennium, “President George W. Bush called for significant reforms at the federal level, which led to the enactment of the *No Child Left Behind Act of 2001*” (Department of Education, 2008, p. 5). This law built upon earlier education reforms and required “that states accepting the federal government’s targeted investment agree to measure and report on results in terms of standards and accountability" (Department of Education, 2008, p. 5). Such reporting to the federal government requires schools to test students at various grade levels in the area of mathematics and reading as well as to report school-level results broken down in order to display results separately for such groups as minorities, disabled students, and other subcategories (Department of Education, 2008). The vision of this law was "to provide rigorous and demanding subject-matter content for all students" (Schmidt, 2004, p. 6) in order to "achieve equity and excellence through standards and accountability" (Department of Education, 2008, p. 7).

The History of Private Education and the Mathematics Connection

The Catholic school sector has had its place in the United States education system from very early in the country's history. Developed during the time of "heavy immigration of Irish, German, Italian, and Polish Catholics to the United States between 1800 and 1930" (Holtz, 1976, p. 296), the curriculum for the first century of the Catholic schools "existence was directly related to the religious and cultural basis for the school's establishment" (Holtz, 1976, p. 296). With a curriculum valued by parents, the school sector grew quickly. By the year 1840, there were 200 Catholic schools positioned close to the local public school in most major cities (Holtz, 1976). By 1900, the debate began in the public school sector in relation to whether a set of core courses was in fact appropriate for all students or whether schools should offer alternatives in order to accommodate for student differences (Lee, Chow-Hoy, Burkam, Geverdt, & Smerdon, 1998). While the public school system chose the more diversified model (Lee et al., 1998), the private schools facing the same dilemma chose a narrower academic curriculum which contradicted the belief in the public school sector that addressed student differences by “diversifying instruction and content”(Lee et al., 1998, p. 316). During this period of the early-20th century, Catholic schools, often bilingual, taught core subjects such as mathematics and science as well as religion in the native language of the particular parish school (Holtz, 1976). Another “pervasive impact on the curriculum flowing from the concept of Catholic schools as cultural havens was the great emphasis on classroom discipline and rote learning” (Holtz, 1976, p. 297). It has been stated that the

> classroom mood, questioning technique, recitation habits, student-teacher interaction, and the uses of instructional materials were all set, and kept for over 100 years in many cases, in large part by the cultural values conservatively clung to by the immigrant population. (Holtz, 1976, pp. 297-298)

By 1964, “5.6 million children were enrolled in over 2,000 Catholic schools” (Holtz, 1976, p. 296) and the Catholic school curriculum had begun to change as a result of the church and its people experiencing changes as well (Holtz, 1976). The former immigrant Catholics, had by this point in time, “acculturated and assimilated into the mainstream of American life” (Holtz, 1976, p. 298) and the “sharp reduction in the number of religious teachers to staff the schools placed curricular development and implementation in the hands of non-religious (lay) teachers” (Holtz, 1976, p. 298). While the Catholic school sector still incorporates religion classes into the curriculum, the public school and Catholic school curriculums have become nearly identical in most other aspects (Holtz, 1976).

Similarly in many ways to the Catholic school sector, independent, non-Catholic, schools, whose "socializing role has always been social reproduction for children of the elite" (Lee et al., 1998, p. 316), "still embrace the tradition shared by all high schools a century ago: preparing students for selective colleges" (Lee et al., 1998, p. 316). Parents who chose such schools in the past and those who choose such schools today share the idea that such an education should "ensure their children's right to belong to the circle of the wealthy and powerful and to serve as society's leaders" (Lee et al., 1998, p. 316). As a result of this consistent mission, there has been little debate throughout the history of independent schools that a college preparatory curriculum is the correct curriculum to offer all students within the sector (Lee et al., 1998), a contrast to the curriculum changes that have occurred in the public and Catholic school sectors.

The 1980's began the debate on the issue of school choice (Parker, 1993) and "although most U.S. adolescents are educated in public schools, about 12 percent were in private schools in 1985-86, and 60.2 percent of the students in private schools were enrolled in Catholic schools" (Lee et al., 1998, p. 317). While financially-able parents have always had choice in their child's education, legislation was introduced at the federal level which proposed the idea of allowing state money to follow a child to any sector, private or public, the parents and child chose in order to give more parents a choice in their child's education (Parker, 1993). The debate continues today with no national programs placed into effect as of yet (Parker, 1993).

Studies comparing the mathematics curriculums of Catholic and private independent non-Catholic schools to that of the public school sector have "found that the private school students took more advanced mathematics courses than did the public school students" (Lee et al., 1998, p. 314). In addition, an examination of the *High School Effectiveness Supplement of the NELS: 88*, found that all of the independent non-Catholic high schools included within the study offered calculus but fewer public high schools offered the course when compared to the Catholic high schools included within the study (Lee et al., 1998).

Private versus Public and the Question about Achievement

Despite having very similar curricula, the great debate of whether public schools or private schools produce the greatest level of student achievement has been at the center of many studies since the early 1980s when one of the most well known reports in this area examined differences between the sectors. In the 1981 report entitled "Public and Private Schools" by James Coleman, Thomas Hoffer, and Sally Kilgore, issues surrounding both sides of the debate were identified and discussed. Attempting to settle the debate about which school provides the most effective education, many follow-up reports, using numerous data sets and analysis techniques, have examined various issues discussed in this initial report. While some researchers support the idea that private schools show the greatest level of student achievement, as proven through the use of national standardized test scores, many other researchers argue that additional considerations must be taken into account before proclaiming one sector more effective than the other (Alexander & Pallas, 1983).

In addition to the initial report "Public and Private Schools", in the early 1980s, James Coleman, with the help of various colleagues, wrote several reports declaring that the school sector students attend can affect their achievement. For instance, in the 1982 article entitled "Cognitive Outcomes in Public and Private Schools", it was found that when comparing students from public high schools to those attending Catholic and other-private high schools, the latter attained a higher level of achievement and growth from sophomore year to senior year especially in the area of mathematics (Coleman, Hoffer, & Kilgore, 1982). Using data from the initial 1980 collection phase of the national longitudinal study known as “High School and Beyond” (HSB) and statistically controlling for variations that naturally occur between public and private school students, it was determined that “private sector sophomores are about at the level of the public sector seniors” (Coleman et al., 1982, p. 68). After accounting for initial differences in background characteristics, through statistical analysis, these significant differences remained.

Despite controlling for differences between the students of the two sectors, many researchers challenged the findings of these initial reports by Coleman and his colleagues because of limitations of the data set used and the analysis methods applied within the studies (Willms, 1985). The article entitled “Catholic-School Effects on Academic Achievement: New Evidence From The High School and Beyond Follow-Up Study” by J. Douglas Willms, published just three years later in 1985, made use of the follow-up data from the second wave of the HSB study. Utilizing measures at two time points, Willms was able to expand on the analysis previously begun by Coleman and his coauthors. Comparing the growth in achievement on outcome measures while still controlling for differences between the students of the two sectors, Willms found a small Catholic-school advantage, not nearly as large as the results previously found by Coleman, in the area of student achievement on advanced mathematical concepts (Willms, 1985). Willms also reported slightly larger disparities favoring Catholic schools between the two sectors when examining results on the general achievement tests included within the data set (Willms, 1985).

With several reports suggesting higher student achievement from the private school sector, by the late 1980s many previous supporters of public education began to question the effectiveness of the schooling sector. One such group of former supporters included African American parents who became increasingly disappointed with the educational results they were experiencing with their children (Jones-Wilson, Arnez, & Asbury, 1992). After decades of fighting for equality and many additional years expressing concerns about the lack of achievement of their youth, by the 1980s many African Americans began choosing nonpublic educational options for their students in an attempt to receive the results they desired (Jones-Wilson et al., 1992). Surveying African American parents/guardians from the Greater Washington, DC metropolitan area about their decision to send their children to nonpublic schools, it was found that most respondents, when asked the reason for not enrolling their student in the local public school, stated it was due to lack of discipline (Jones-Wilson et al., 1992). Additional concerns about the local public school system included inadequate curriculum and educational goals and standards as well as overcrowded classrooms that lacked individualized attention (Jones-Wilson et al., 1992). African American parents' desire for more individualized attention, smaller student-teacher ratios, an environment sheltered from the dangers of drugs and violence, and a higher quality education with advanced resources were commonly stated reasons for choosing to enroll their child in a local private school (Jones-Wilson et al., 1992).

The parents surveyed have support from several researchers who have found similar problems through their research on the public school system. For instance, it has been stated that inner-city school districts lack “strong social networks in which norms, expectations, trust, and a sense of interpersonal obligations prevail” (Gamoran, 1996, p. 42) and “schools with specially focused missions are needed to help overcome this family and community breakdown” (Gamoran, 1996, p. 42). Furthermore, many comprehensive public high schools tend to have goals that are unfocused and consequently “often fail to provide students with strong academic guidance and a sense of purpose and fail to engage students in serious academic work” (Gamoran, 1996, p. 43). It has been suggested that “Catholic and independent schools, with their distinctive missions, might better serve many students’ needs” (Gamoran, 1996, p. 43). To support such statements, Adam Gamoran compared student achievement from the different school sectors using data from the NELS: 88. Statistically controlling for “the students’ prior achievement, gender, race, ethnicity, and family structure, and for the different compositions of the schools” (Gamoran, 1996, p. 44), it was found that in the area of mathematics, students from Catholic schools ranked higher than students in comprehensive public schools and the results showed statistically significant differences between the two sectors (Gamoran, 1996). In an attempt to explain such differences in the school sectors, Gamoran examined three conditions including the school climate, the students’ social bonding to the schools, and the number of courses taken by students in the areas of mathematics and other core subjects (Gamoran, 1996). Measured by surveys given to principals and students of the schools included within the data set, the previous conditions received quantifiable values. It was concluded that the three “conditions did account for the

Catholic school students' achievement advantage in math over that of the public comprehensive school students" (Gamoran, 1996, p. 45).

Another study conducted just a year later in 1997 and using the same NELS: 88 data set, attempted to "identify the organizational characteristics of high schools that make them better places for students to learn" (Lee, Smith, & Croninger, 1997, p. 128). Controlling for differences between student populations and school characteristics, findings suggested that schools reporting using atypical structural practices had advantages in student achievement over those schools reporting no structural practices (Lee et al., 1997). Schools classified as atypical included practices such as an "emphasis on staff solving school problems" (Lee et al., 1997, p. 143), "parents volunteer in the school" (Lee et al., 1997, p. 143), and "mixed-ability classes in mathematics/science" (Lee et al., 1997, p. 143). A majority of private schools reported using atypical practices that departed substantially from the conventional educational practices whereas schools reporting no structural practices were generally disadvantaged when compared to those using traditional and atypical practices (Lee et al., 1997). In addition, it was found that schools utilizing atypical practices were advantaged in the following areas: "students took more mathematics and science courses and there was less variability in course taking, instruction was more authentic, authentic instruction was more homogeneous across classes, and these schools had higher levels of academic press" (Lee et al., 1997, p. 136). Such results led the researchers to state, "schools with atypical structural practices have stronger academic organizations" (Lee et al., 1997, p. 136). It was also determined that these results were dependent on the fact that a large proportion of private schools use this particular structural practice and therefore such factors must be taken into account before solid conclusions can be made from the results (Lee et al., 1997). Bearing in mind such considerations, the numerical results still favored the atypical practices characteristically used by private schools (Lee et al., 1997). For instance, the results indicated that high school students learned more in the area of mathematics from schools with atypical practices and the learning was more equitable in such schools (Lee et al., 1997). Similarly, findings suggest that the influence on academic achievement might be due to "broader organizational attributes that reflect the willingness of schools to adopt and stick to policies and practices that move them away from bureaucracies toward communities with a strong academic focus" (Lee et al., 1997, p. 141). In his 2006 article, Gerald Bracey provided a very similar argument when he stated that people might expect the private school sector to show greater student achievement since, "they have less bureaucracy, no controversies over textbook adoptions, and a commitment from parents to their children's education that might be greater than that of those who do not choose their children's school" (p. 636).

Possibly, as a result of the previous findings, many policy changes took place within the public sector in the late 1990s and into the turn of the century in an attempt to close the sector gap in achievement (Carbonaro & Covay, 2007). From Goals 2000 to NCLB, reform movements attempting to increase teacher and school accountability, student achievement, and academic standards have become a part of the public sector (Carbonaro & Covay, 2007). In the article entitled "Sector Differences in Student Experiences and Achievement: An Update", William Carbonaro and Elizabeth Covay from the University of Notre Dame attempted to determine if such recent policy changes influenced the level of student achievement in the nation's public schools. Using the most recent national education data set, the ELS: 2002, information was obtained on "students' family background, future educational ambitions, academic experiences, and academic achievement" (Carbonaro & Covay, 2007, p. 8). The ELS data set

> provides measures of students' proficiency in math. These proficiency scores indicate the likelihood that a given student has mastered a given level of math skills. ELS devised five skill levels: (1) simple arithmetical operations on whole numbers, (2) simple operations with decimals, fractions, powers, and roots, (3) simple problem solving, requiring the understanding of low-level mathematical concepts, (4) understanding of intermediate concepts and/or multi-step solutions to word problems, and (5) complex multi-step word problems and/or advanced mathematical material. For both tenth and twelfth grade, students' test scores were translated into a probability that they were proficient at each level. (Carbonaro & Covay, 2007, p. 9)

Using several statistical analysis methods, including regression and matching as well as correcting for design effects, many findings still supported the superiority of the private sector. For instance, it was found that "private school students enjoy greater achievement gains in math from tenth to twelfth grade than public school students" (Carbonaro & Covay, 2007, p. 15) and this "Catholic and private, non-Catholic school advantage in achievement gains is roughly 25-30% greater than the average public school achievement gain" (Carbonaro & Covay, 2007, p. 15). When examining the five proficiency levels previously described, it was found that while nearly all students, regardless of school sector, attained the lowest level of proficiency, private school students were considerably more likely to be proficient at the second, third and fourth levels than public school students of the same age (Carbonaro & Covay, 2007).

These achievement levels relate directly to the findings of course taking pattern differences between the sectors. In particular, findings showed that “two-thirds of private school students take trigonometry, pre-calculus, or calculus as their highest math course” (Carbonaro & Covay, 2007, p. 16) while only 44.3% of public school students persist in the area of mathematics up to such levels (Carbonaro & Covay, 2007). In addition, it was reported that students attending the public school sector “were also less likely to take math in twelfth grade: thirty-seven percent of public school students opted out of math as seniors, whereas only about a fifth of private school students went without a senior math course on their transcript” (Carbonaro & Covay, 2007, pp. 16-17). Using both the 1988 NELS data set and the 2002 ELS data set, to compare changes over the past decade in public schools, research found that students within the public school sector made some notable gains (Carbonaro & Covay, 2007). For instance, in just a decade, the percentage of public high school students going as far as Algebra II rose a quarter to 75% (Carbonaro & Covay, 2007). Despite such findings, Carbonaro and Covay stated that “the data strongly indicate that private school students have a more rigorous academic experience in high school math than public school students” (2007, p. 17) and that “important sector differences in academic experiences remain” (2007, p. 23).

Research claiming that the public school sector provides students the opportunity for greater academic achievement is just as prevalent as the research claiming the previous side of this debate. The 1983 article entitled “Private Schools and Public Policy: New Evidence on Cognitive Achievement in Public and Private Schools” was written to refute the original documents on this debate written by Coleman and his colleagues (Alexander & Pallas, 1983). Criticizing the analysis performed in those original reports, Karl Alexander and Aaron Pallas from John Hopkins University used the data from the National Longitudinal Study of the Class of 1972 as well as the data from the High School and Beyond study in order to "examine public-Catholic sector differences within high school tracks for a variety of cognitive and achievement outcome measures" (Alexander & Pallas, 1983, p. 170). Performing their own data analysis that included controlling for the differences in student selection processes as well as students' background characteristics, it was determined that only slight, insignificant differences existed and, therefore, the claim in Coleman's original documents that "Catholic schools produce better cognitive outcomes than do public schools" (Alexander & Pallas, 1983, p. 170) was unfounded. Willms, in his 1985 report, found similar results to those reported just two years earlier by Alexander and Pallas. Analyzing the High School and Beyond data set, Willms found that "on the basis of the results for the curriculum-specific tests, the study suggests that there is no pervasive Catholic-school effect on academic achievement" (1985, p. 112). Furthermore, the results for the basic mathematics skills test indicated only "a small, statistically significant Catholic-school advantage of about 7 to 10 percent of a standard deviation" (Willms, 1985, p. 112). Despite the statistical significance, Willms argues that such findings are not practically significant because "an effect of 10 percent of a standard deviation is enough to change a student's rank in his or her class from the 50^{th} to the 54^{th} percentile" (1985, p. 112) and "scores of freshmen in the most selective universities are about two full standard deviations higher than the scores of freshmen in mediocre state colleges" (1985, p. 112).

Researchers supporting the public school sector often use data from the National Assessment of Educational Progress (NAEP) assessments. For instance, the 1998 article entitled "About Those Private School Achievements" examined the 1996 NAEP science results and found that the differences between the private and public sectors became smaller as the grade level increased and concluded that "the differences at the low end of the percentile scale are probably the result of selection factors: private schools taking the students they want; public school taking whoever walks in the door" (Bracey, 1998, p. 629). Likewise, in the 2005 article, "A New Look at Public and Private Schools: Student Background And Mathematics Achievement", achievement and survey data collected in the 2000 NAEP mathematics assessment was used to "examine the question of whether the widely assumed 'private school effect' is due more to the population of students served than to institutional effectiveness" (Theule Lubienski & Lubienski, 2005, p. 697). It was found that when comparing the mathematics achievement averages of the private and public school sectors, after having been broken into four socioeconomic status (SES) quartiles, that the public school average was "higher than that of the corresponding private school mean at both grades 4 and 8" (Theule Lubienski & Lubienski, 2005, p. 698). It was also emphasized that

> within each subgroup, public school means are higher than private school means, the overall private school means are higher than public school means because of the larger proportion of higher-SES students in private schools. These results call into question common assumptions about public and private school effects and highlight the importance of carefully considering SES differences when making

> comparisons of school achievement. (Theule Lubienski & Lubienski, 2005, pp. 698-699)

Bracey's 2006 article entitled "Public Schools: Outscoring the Privates" examined a follow-up article by Theule Lubienski and Lubienski, which analyzed data from the 2003 NAEP mathematics assessment. Bracey emphasized that their second research report found very similar results as the original including findings that support the work of the public school sector (2006). For instance, it was found that after controlling for demographic differences between the two sectors, "for all categories of private schools, the achievement relative to public schools reverses, sometimes dramatically, and the public schools score higher" (Bracey, 2006, p. 636).

The 2008 article, "What Do We Know About School Effectiveness? Academic Gains in Public and Private Schools", examined data from the national longitudinal study Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K) in an attempt to determine whether public school students and private school students, demographically equivalent, begin kindergarten with similar levels of academic achievement (Lubienski, Crane, & Theule Lubienski, 2008). Analyzing "the data on student and family characteristics, school type, and mathematics achievement from kindergarten through fifth grade" (Lubienski et al., 2008, p. 692), it was determined that the initial kindergarten achievement of students in both sectors were nearly identical and "that public school students outperformed Catholic school students by the fifth grade and rivaled the performance of students in other private schools" (Lubienski et al., 2008, p. 693). The difference between the Catholic school students and the public school students by the fifth grade statistically "indicates that public school students had gained almost an extra half year of schooling" (Lubienski et al., 2008, p. 693). The authors concluded that the findings provided evidence that "public schools are at least as effective as private schools in boosting student achievement" (Lubienski et al., 2008, p. 694).

Through the research conducted and reports written on this issue, researchers have stated many possible solutions that may help to end this issue and debate. In the 2008 article by Lubienski, Crane, and Theule Lubienski, it was stated that "the next wave of insights into the question of school effectiveness can be best gained by moving away from a simple focus on school type and instead examining what happens within schools" (2008, p. 694). Researchers studying this area of sector differences have given the following suggestions. For instance, in the article entitled "Characteristics Associated With Effective Public High Schools", it was stated "that the number of science and mathematics courses, the percentage of students in academic programs, and the number of discipline rules enforced in school are positively and significantly related to student test scores" (Harnisch, 1987, p. 234). Therefore, school officials should consider ways to promote competency requirements because such requirements "encourage young people to take their educational responsibilities more seriously and improve their performance as a result" (Harnisch, 1987, p. 239). Similarly, it was stated in a different report that schools with "a narrow and academic curriculum, with a strong organizational push for all students to take (and master the content of) these courses" (Lee et al., 1997, p. 142) show greater achievement than schools "offering a broad range of courses at many different levels and encouraging students to select courses according to their 'personal tastes' (the universalistic model)" (Lee et al., 1997, p. 142). Lastly, it has been suggested "that public and private schools need to focus more energy and resources on teaching high level math skills to their students" (Carbonaro & Covay, 2007, p. 33) and an adequate measure of achievement needs to be created in order to accurately determine academic growth for students (Willms, 1985).

In conclusion, the debate about whether the private or public school sector provides students with a greater opportunity to achieve at higher levels continues into the 21st century. While research has shown positive and negative results for both sectors, the debate continues with new findings and ever-increasing suggestions. Despite using numerous sets of data as well as analysis techniques in an attempt to answer this question, researchers continue to disagree as to what the results suggest in the context of this debate, which began many decades ago.

A Comparison on the Claims of a Possible Mathematics and Science Crisis

Another frequently debated topic surrounding the area of mathematics is the idea of a possible shortage in mathematicians and lower standards for students in mathematics courses at all levels of education. Since the Soviet Union sent up the world's first satellite into space, many experts in the United States have been proclaiming that the country is in a mathematics and science crisis. The launch of Sputnik in 1957 created the United States' first concern about its ability to remain competitive in such areas as math and science when compared to other rising nations (Friedberg, 2009). Since that initial source for concern, there have been and continues to be, even into the 21st century, many experts claiming that the United States is at risk of falling behind as a competitive nation (Friedberg, 2009). However, there are also many experts who believe that the fear generated by such accusations is unwarranted and there is no such crisis (Monastersky, 2004).

From ill-prepared teachers to students failing early on in the sciences and lacking the interest to pursue such areas further, those who believe that the United States currently has a math and science crisis state many reasons for why they believe this as well as many solutions they believe need to be taken in order to solve the problem. For instance, Solomon Friedberg, a Boston College professor of mathematics and member of the Massachusetts Board of Education's Math-Science Advisory Council, addressed the math and science crisis in a June 2009 article in the *Business West* journal. Believing that there is a math and science crisis in America, Friedberg (2009) stated that the nation is "in a feedback loop with today's ill-prepared students becoming tomorrow's teachers" (p. 12). He went on to support this statement with an example from an announcement made that particular week "that nearly three-quarters of aspiring elementary school teachers failed the math section of the state's licensing exam" (Friedberg, 2009, p. 12). The fact that students ill prepared in the subject of mathematics were going into the field of education was less than a surprise. In June 2008, the National Council of Teacher Quality "reported that the average 2007 mathematics SAT score of high-school seniors planning to major in education in college was 32 points below the national average for all college-bound students" (Friedberg, 2009, p. 12). Most would hope that these ill-prepared students would learn what they need to know in their college courses in order to prepare their students better but when the National Council of Teacher Quality examined 77 education schools, "it rated 37 of them as 'fail on all measures' in preparing elementary teachers to teach math" (Friedberg, 2009, p. 12). Similarly, in a 2005 article by Thomas Sowell, it was stated that in a recent report from the United States Department of Education that "in 28 of the 29 states that use the same standardized test for teachers, it is not even necessary to come up to the national average in mathematics to become a teacher" (p. 21).

The lack of well-prepared teachers within the elementary and secondary schools in the United States could be increasing the number of students who struggle and fail early on in their mathematics and science experiences. In the article entitled "The New Mythology About the Status of U.S. Schools", published in a 1995 edition of the journal *Educational Leadership*, the author Lawrence Stedman describes the crisis as it was right before the 21st century began. Describing United States student performance on international mathematics tests as dismal, Stedman explained how in "1991, for example, the United States finished 14th out of the 15 countries whose populations were comprehensively sampled" (1995, p. 82). Stedman further explained how an analysis of NAEP results, in 1995, concluded that, amongst high school seniors, less than half appeared to have a complete understanding of content that was taught during the seventh grade. Furthermore, only 5% performed at the level typical of students familiar with algebra and geometry, even though most of the students had taken these two courses prior to their senior year. Now in the 21st century, the same statements, described prior to the turn of the century, are under discussion today. For instance, in an article published in the summer of 2009, it was noted "U.S. students lag behind industrialized nations on student assessment scores. (For instance, the U.S. is the fourth-lowest performing country among 29 recently surveyed by The Program for International Student Assessment.)" (Malone, 2009, p. 30).

Due to the nation not producing well-qualified teachers in the areas of math and science as well as students failing early on in such areas, these problems could be affecting the number of students who choose to pursue such areas. The lack of post-secondary students pursuing the sciences is another often-stated reason for believing the nation is in crisis. The article entitled "Students Who Study Science, Technology, Engineering, and Mathematics (STEM) in Postsecondary Education" by Xianglei Chen produced for the United States Department of Education in July 2009, gives a picture of the current situation in such areas. For instance, using a nationally representative sample of undergraduate students from the 2003-2004 National Postsecondary Student Aid Study (NPSAS: 04), it was found that only

> 14 percent of all undergraduates enrolled in U.S. post secondary institutions in 2003-04 were enrolled in a STEM field, including 5 percent in computer/information sciences, 4 percent in engineering/engineering technologies, 3 percent in biological/agricultural sciences, and less than 1 percent in physical sciences and mathematics. (Chen, 2009, p. 3)

Similar results were found when the Educational Longitudinal Study of 2002/06 (ELS: 02/06) was used to examine only students of traditional college age. It was reported that "15 percent of 2003-04 high school graduates enrolled in postsecondary education in 2006 reported a STEM major" (Chen, 2009, p. 3). Using data from the 1995-96 Beginning Postsecondary Students Longitudinal Study (BPS: 96/01), it was found that 23% of students beginning at the postsecondary level entered a STEM field at some point in their postsecondary enrollment. Of that total, "a higher percentage of students entered biological/agricultural sciences, engineering/engineering technologies, and computer/information sciences (7-8 percent) than mathematics and physical sciences (less than 2 percent for each)" (Chen, 2009, p. 4). Using the BPS: 96/01 data and comparing the students' majors of when they first began to their majors when they were last registered through 2001, 36% were no longer enrolled in STEM fields and 24% of students who were initially mathematics majors had changed to a different STEM major at some point throughout the study (Chen, 2009). Many experts across the disciplines believe that the low rates of college enrollments into such areas as mathematics, science, and engineering could threaten America's ability to compete globally with other rising nations (Malone, 2009).

As numerous as the reasons believed to be causing the crisis are, so too are the explanations of how to fix the problem. A few initiatives are currently in action throughout the country during the 21st century. Understanding that steps must be taken to combat the problem, many federal and state legislatures have created efforts aimed at developing STEM educational programs especially in the areas of mathematics, engineering, as well as the natural sciences (Chen, 2009). In a 2007 study conducted by the Center on Education Policy, just five years after the NCLB act was implemented, approximately "62 percent of districts had increased instructional time for English or math, or both, in elementary schools, and more than 20 percent reported increasing time for these subjects in middle school" (Zhao, 2009, p. 39). In addition, corporate America has created many programs aimed at increasing both the skills and interests in the areas of science and mathematics. For instance, The Partnership for 21st Century Skills, an initiative generated by several corporations, formed a list of 21st century skills for both elementary as well as high school students. One such skill listed by the corporations, as being very important in the 21st century workplace, is the ability to think and problem-solve critically as well as creatively (Malone, 2009). Supporting that idea, Tony

Wagner, author of the 2008 book *The Global Achievement Gap*, repeated the need for such skills as well as the ability to analyze data, which consequently emphasizes the need for a great mathematics understanding (Malone, 2009). Other corporations such as the Howard Hughes Medical Institute, the NAACP, Stanford University, and Philip Morris USA, have begun programs such as Health Sciences and Technology Academy (HSTA), Academic, Cultural, Technological and Scientific Olympics (ACT-SO), Stanford Medical Youth Science Program, and Math and Science Investigators (MSI), respectively, which are offered to encourage minority students, as well as students of lower socioeconomic status, to pursue careers in the areas of mathematics, science, and technology (Adams, 2006).

Others believe that in order to overcome the crisis we need to do more to garner support for the areas of math and science. For instance, some people suspect that until the stereotypes and stigmatisms that surround the areas of math and science disappear, the nation may always have a shortage of students pursuing the areas. Jeff Weinstock, author of the 2006 article “Math Needs a Makeover”, believes that mathematics is in need of a new image because technology has done all it can presently do in order to make the subject easier and less abstract but it has yet to increase the likeability or perception of mathematics to students of all ages. Still, some believe that in order to end the crisis the government needs to implement more laws. Friedberg believes his idea for a Mathematics and Science Education Act would help break the cycle. The principal points of his proposal include ideas such as providing financial incentives to mathematics and science students to attract them into the field of education, ensuring that along with teaching skills, education students receive a thorough understanding of their subject area, as well as increasing the professional expectations, opportunities, and salaries for mathematics and science teachers (Friedberg, 2009).

It was predicted “that by 2012 the United States will have 1.25 million more positions in the science and engineering fields, including biology, ecology, anthropology, and computer and mathematical sciences” (Adams, 2006, p. 28). Experts believe that in order to overcome the shortage we are currently experiencing, we must utilize the potential in African American students who will soon become the majority. As of 2006, only 6% of the researchers, mathematicians, scientists, and engineers out in the workforce were African American or Hispanic (Adams, 2006). Although many government and private agencies, such as, “The National Science Foundation, the National Institutes of Health (NIH), the Department of Defense and the Department of Education” (Adams, 2006, p. 30) are funding programs meant to increase the participation of minority students in the fields of mathematics, science, and technology, more must be done to overcome the crisis. Thus, no matter what the reason believed to be for the crisis, experts think that in order for America to stay economically competitive in this global society, a renewed interest in science and mathematics education must begin.

On the contrary, many people believe that no such crisis exists in America and they have their own numerous explanations to support such beliefs. For instance, many supporters believe that inaccurately reported statistics by the government and corporations use the “crisis” as a fear tactic to promote their agenda, and people have fallen for the assumption that high scores on international tests will result in economical gains for the country (Bracey, 2003). With so many predictions and warnings about a presumed upcoming mathematics and science crisis that never amounted to anything, many researchers and experts are becoming skeptical of the statistics used to support the crisis idea (Viadero, 2006). Those who support the idea of a crisis believe there is a lack of students pursuing the areas of mathematics and science but a record number of American students were earning bachelor's degrees in the areas as of the year 2004 (Monastersky, 2004). In addition, according to the 2006 "annual Survey of the American Freshman by the University of California, Los Angeles, one-third of first-year students at the 385 four-year institutions surveyed intended to major in a science or engineering field – a proportion that has not changed since 1972" (Viadero, 2006, p. 21). Although the percentages of students entering STEM fields are small in comparison to other majors, there is some good news for the students who do pursue such degrees. It was reported by Chen that when comparing students who enter STEM programs to students who do not pursue STEM areas, "those entering STEM fields had a higher rate of completing a bachelor's degree" (2009, p. 7) and had "a lower rate of leaving college without earning any degree" (2009, p. 7). Similarly, the National Science Foundation warned in May 2004 that the number of American students obtaining graduate degrees was declining when in actuality the number of United States citizens enrolling in graduate programs in the areas of engineering and all the science fields was in fact increasing (Monastersky, 2004).

From the time Sputnik went up into space to the report *A Nation At Risk* was released to the time NCLB was passed, the government and private corporations have been predicting and warning of terrible outcomes that never happened in order to endorse their own interests. Terrel Bell, the Secretary of Education who assembled the National

Commission of Excellence in Education in the report *A Nation at Risk: The Imperative for Educational Reform*, admitted in his memoir that he wanted an occurrence like that of Sputnik, which occurred nearly 30 years earlier, because it would dramatize all the complaints about the effectiveness of American education that he kept receiving (Bracey, 2003). *A Nation at Risk* reported a national economic collapse would occur if immediate reform in the American educational system was not accomplished (Bracey, 2003). The report called for the same recommendations that are being sought currently in the 21st century which include more science and mathematics, more instructional time each school day, as well as more highly-qualified teachers. However, the dire predictions never resulted and, in fact, quite the opposite occurred, as the United States productivity level soared. Many people believed "the report was a veritable treasury of slanted, spun, and distorted statistics" (Bracey, 2003, p. 617), including Peter Applebome of the 1983 *New York Times* who called the risk allegations simply propaganda (as cited in Bracey, 2003).

Politicians and corporations into the 1990s and into the current 21st century keep the dire warnings issued by *A Nation at Risk* alive. Hyping alleged bad news about the public schools and suppressing potential good news, critics such as the CEOs of Xerox, Texas Instruments, and Intel all wrote about the poor quality of the school system in national newspapers (Bracey, 2003). When engineers working at Sandia National Laboratories reported that while there were numerous problems within the United States public school system, there was no system-wide crisis, the Secretary of Energy, the Assistant Secretary of Education, and the CEO of Xerox all denied the report's findings and suppressed the document from further publication and dispersion (Bracey, 2003).

Surprisingly, many universities around the country have also kept the idea of a nationwide crisis in the news as well. "The National Commission on Excellence in Education commissioned more than 40 papers that laid out the crisis" (Bracey, 2003, p. 621) and nearly all of them were submitted by those in academia who see the idea of a crisis as a great opportunity to receive money from various foundations and government agencies (Bracey, 2003). Likewise, the National Science Foundation warned in the mid-1980s that the nation would not have enough engineers and scientists to fill positions in academia but those projections proved inaccurate. As of 2004, some observers believed that American universities were preparing too many engineers and scientists because many graduates were unable to find positions and some even went as far as to suggest that the universities arranged such a situation in order to keep labor costs down while keeping productivity high (Monastersky, 2004).

Besides promoting their own agenda and inaccurate statistics to promote the idea of a crisis, the government and corporations have also led the citizens to believe that high scores on international tests will result in economical gains for the country. *A Nation at Risk* implied that high test scores demonstrated the competitiveness of a nation without presenting any data to support such a claim except for many people using Japan as an example of such a country that had high test scores on international tests and was experiencing economical gains as a nation (Bracey, 2003). However, "the National Commission on Excellence in Education—and many school critics as well—made a mistake that no educated person should: they confused correlation with causation" (Bracey, 2003, p. 619). The historian Lawrence Cremin, author of *Popular Education and Its Discontents*, elaborated on the issue and believed the claims presented in *A Nation* *at Risk* were nonsense (as cited in Bracey, 2003). He believed that trying to solve the problems of international competitiveness through school reform was foolish and that it laid the burden of responsibility on the school system rather than on those who should actually be responsible for the task of increasing competitiveness (Bracey, 2003). In his 2003 article, Bracey tested the hypothesis that competitiveness correlated with economical success for a nation. Examining the nations that took part in the Trends in International Mathematics and Science Study (TIMSS) as well as the nations ranked by the World Economic Forum (WEF) for global competiveness, the United States was ranked second in global competitiveness just behind Finland, which did not participate in the first part of the TIMSS study (Bracey, 2003, p. 619). Bracey concluded that the *Nation at Risk* report "fabricated its case for the connection between education and competitiveness" (2003, p. 619). Those in government, academia, and business extended this idea of competitiveness to the area of the United States educating too many students from other rising nations. Many believe that once the students graduate they will return to their respective countries and their capabilities will profit the other nations (Monastersky, 2004). However, the National Science Foundation reported in 2004 that 76% of these students intended to work for the United States after receiving their Ph.Ds. (Monastersky, 2004) and hence, once again, no such crisis truly existed.

There are several suggestions as to what needs to happen in the future in order to prevent problems from further talk of a crisis in mathematics and the sciences. Researcher and Duke University engineering professor, Vivek Wadwha, "worries that the hype generated by the earlier, incorrect estimates effectively will become self-fulfilling prophecies as young scholars flock to nonengineering professions that they think are 'outsourcing-proof'" (Viadero, 2006, p. 21). He believed that researchers and policymakers needed to pinpoint specific categories within the broader fields before claiming future potential shortages. Furthermore, Warren Washington, chair of the National Science Board, believed that universities needed to move away from the narrow objectives currently used and focus on educating in a much broader context (Monastersky, 2004). The real mathematics and science crisis may not be one of quantity but rather quality (Monastersky, 2004). Lastly, many experts would like to see correct statistics attached to studies that predict future problems connected with the United States educational system (Monastersky, 2004).

In summary, while many experts believe that there has been and continues to be a mathematics and science crisis in the United States many others believe that the past calls of crisis proved to be false and continue to be false even on the most recent developments. Both sides will argue statistics and solutions until the two can find common ground. With predictions made, only time will tell which side of this issue will be deemed correct.

A Comparison on the Claims of Gender Difference in Mathematical Ability

Another debate surrounding the area of mathematics is the question of whether biological gender affects one's ability in the subject. Once outnumbered at the post-secondary level of education, women have been making gains in obtaining advanced degrees over the past 30 years (Sax, 1996). However, at every educational level, women are still underrepresented in the scientific fields. In 1980, women represented only 19% of mathematicians in the labor force (Ware, Steckler, & Leserman, 1985) and by "1981, only 27 percent of the nation's bachelor's degrees in science and mathematics were awarded to women" (Ware et al., 1985, p. 73). Similarly, in 1981, "only 17 percent of all science and mathematics doctorates went to women" (Ware et al., 1985, p. 73). In 1995, using data from the National Science Foundation, it was reported that women were "earning 33 percent of bachelor's degrees, 25 percent of master's degrees, and 22 percent of doctoral degrees" (Sax, 1996, p. 2) in the areas of science, mathematics, and engineering. Just three years later, in 1998, reports declared that women earned 37% of the science, mathematics, and engineering bachelor's degrees (Chang, 2002). In 1999, just before the turn of the century, 46% of the United States workforce was comprised of women but only 24% of the science and engineering workforce was made up of women (Halpern, Benbow, Geary, Gur, Hyde, & Gernsbacher, 2007).

Although the numbers have been rising, the need for skilled scientists and mathematicians in the 21st century has brought this issue of the underrepresentation of women in the science fields to the forefront. It was predicted in 2002 that over the span of the next 10 years, the United States would need to educate an additional 1.9 million people in the sciences in order to keep up with the country's needs (Chang, 2002). In order to fulfill the country's demand for workers in the sciences, increased participation will need to come from this underrepresented group of females. Just a year later, in 2003, a similar call to action came from the National Science Board. Predicting critical shortages in careers that require high-level skills in the fields of science and mathematics, the National Science Board feared that with a decrease in the number of American mathematicians and scientists, the country may not be able to continue leading in the areas of science and technology (Halpern et al., 2007). At the same time, economists warned that without an increase of students pursuing the areas of mathematics and science, the economic growth of the country could decline and threaten the economic security all together (Halpern et al., 2007). Despite these warnings, students are continually being lost in the fields of science, mathematics, and engineering throughout the educational system. Women now make up the majority on many university campuses and are just as likely as males to take advanced classes in the areas of mathematics and science while in high school; but upon entering the university level, women are less likely to pursue a degree in the areas of mathematics and science (Zeldin & Pajares, 2000). In addition to the lack of participation, many women who begin in such majors at the university level eventually leave in pursuit of other options (Zeldin & Pajares, 2000).

The lack of participation and persistence by women in the areas of mathematics and science has led to questions about possible gender differences that could explain the underrepresentation of women. Throughout its history, the area of scientific psychology has examined possible gender differences in the cognitive abilities required for success in the areas of mathematics and science (Halpern et al., 2007). Beyond differences in cognitive abilities, other possible reasons offered over the course of history attempt to explain the discrepancies in the achievements of men and women in the areas of mathematics and science (Ware et al., 1985). In the article entitled "Undergraduate Women: Who Chooses a Science Major?" a given list provided some of the most popular possible explanations for the differences between the genders. The list includes such items as innate ability, socialization processes that equate such careers with men, as well as women's lack of confidence, role models, and preparation in the areas of math and science (Ware et al., 1985). The debate of whether men and women differ in ability continues into the 21st century.

Some experts believe that there is a difference in ability between the genders and state reasons such as biology and perseverance to support their ideas while others believe that there is no difference in the abilities of men and women when it comes to mathematics and science. This side of the debate suggests that different aspects of the society in the United States cause the differences.

In January 2005, the then president of Harvard University, Larry Summers, gave a speech on the gender gap in academic positions in the areas of science and mathematics. One explanation he offered for why a lower percentage of women pursue advanced degrees in mathematics and science was that men might have an innate ability to succeed in those areas when compared to women (Ripley, 2005). He drew this assumption from the fact that fewer women earn degrees in those areas and more men achieve at higher levels on ability tests in advanced mathematical areas (Halpern et al., 2007). The idea of an innate ability often implies biological differences between the genders and many researchers have explored the brain in an attempt to explain this achievement gap (Halpern et al., 2007). A majority of the literature on this subject of gender differences within these areas is often based on verbal, visuospatial, and quantitative abilities, which are three core cognitive abilities closely linked and necessary in learning and performing in the areas of mathematics and science (Halpern et al., 2007). Verbal abilities apply to language skills while visuospatial abilities apply to the storage, retrieval, and processing of information (Halpern et al., 2007). Both verbal and visuospatial abilities are intertwined with the various numerical problems and skills under the title of quantitative abilities (Halpern et al., 2007). Many experts who believe there are biological differences that account for the disparities in mathematics and science performance between the genders often refer to differences found in visuospatial abilities (Halpern et al., 2007). Much of the research has revealed that for some measures of visuospatial information processing, there are substantial differences between men and women and these differences often become apparent beginning around the time children enter kindergarten (Halpern et al., 2007). Using various measures of visuospatial abilities, closely connected to success in the fields of mathematics and science, research found that preschool boys, on average, "are more accurate than girls at spatial tasks that measure accuracy of spatial transformations" (Halpern et al., 2007, p. 8). Doreen Kimura, a psychology professor who believes Harvard's president may have a valid point, explained in a 2002 article entitled "Sex Differences in the Brain" that the different wiring in the brains of boys and girls have allowed boys, around the age of three, to mentally rotate figures better than girls of the same age (Fogg, 2005). Many experts who support the idea that cognitive differences create the gap in achievement between men and women further defend their opinion using the finding that mathematical and visuospatial skills "appear to be more strongly linked in females than males, suggesting that females may be particularly hampered in mathematical domains if they have reduced visuospatial skill" (Halpern et al., 2007, p. 9) which has been shown to occur in females of various ages.

The medium to support the idea of biological cognitive differences between the genders most often uses quantitative abilities. Differences between men and women are displayed on quantitative tests such as the mathematics portion of the SAT as well as other high-stakes tests (Halpern et al., 2007). In a 1980s study of gifted seventh-graders, it was found that "the number of boys scoring 700 on the math SATs overwhelmed girls by 13 to 1" (Eisenstadter, 2002, p. 33) which would place them in the 99th percentile at that age range. Using other national math tests, researchers have found similar results in earlier grades as well which suggests, for supporters of innate differences between genders, “that the results come in large part from nature, not just nurture” (Eisenstadter, 2002, p. 33). Using the fact that the SAT is not designed to strictly test classroom taught concepts, some experts take the gender difference on this test to show that “more bright young men are able to manipulate numbers and interpret them with insight—they have better math instincts—than bright young women” (Eisenstadter, 2002, p. 33).

Many experts who support the idea of innate abilities in mathematics favoring the male gender more often than the female gender also turn to studies on gifted students. For instance, researchers studying preschoolers found that, even at this very young age, males outnumbered females after conducting testing to identify students gifted in the area of mathematics (Halpern et al., 2007). Similar findings at the kindergarten and second-grade levels have led some experts to the conclusion that:

> the implications of these differences, and especially of the disparate ratios at the top for the math-science education pipeline, are clear: Given an early advantage in these fundamental quantitative skills, a greater number of males than females will qualify for advanced training in disciplines that place a premium on mathematical reasoning. (Halpern et al., 2007, p. 14)

A similar study involving gifted students found that among students who scored at or above 390 on the mathematics section of the SAT at the age of 13, putting them in the top 1% for their age group, the gifted female test takers had broader abilities than the male test takers (Monastersky, 2005). The females’ scores on the mathematics and verbal portions of the SAT indicated a greater sense of balance than did the scores of the males.

However, the imbalance found in the gifted males favored the mathematics portion of the test and this quantitative imbalance proved to be a significant factor in the choice of a post-secondary major (Monastersky, 2005). This study of gifted students concluded, "students with exceptional math abilities were less likely to major in math or science if they also had high verbal abilities" (Monastersky, 2005, p. A4). Hence, a greater percentage of the gifted females, compared to the males, pursued their other abilities and eventually majored in the life sciences and humanities (Monastersky, 2005). This balance between the verbal and quantitative abilities in females has shown to have an impact on how they solve complex problems (Halpern et al., 2007). A separate study found that females use the language region of the brain to solve the same complex problems that males solved using the spatial region of the brain (Halpern et al., 2007) which emphasizes the fact male and female brains work differently.

Many experts believe that hormones present in the brain alter the ability to perform certain cognitive tasks (Monastersky, 2005). Recent studies have led many researchers to believe that hormones found in the male brain predispose them to better mathematical ability. One study, examining the developmental disorder known as autism, drew conclusions about the differences in male and female brains as it relates to mathematical issues. Believed that the condition is caused by an excessive amount of testosterone while in the womb, autism is more common in boys and is said to cause an "extreme male brain" ("Birdbrained", 2005, p. 33). "Those who have it tend to be better at puzzles and pattern-related tasks than at verbal communication" ("Birdbrained", 2005, p. 33) and medical descriptions of the disorder mention that "autistic minds are often far more comfortable with virtual realms of math, symbols and code" ("Birdbrained", 2005, p.33). "Simon Baron-Cohen, a professor of psychopathology and director of the autism research center at Cambridge" (Monastersky, 2005, p. A1) believed that "boys are born with an interest in figuring out how systems work, while girls naturally focus more on understanding the mental state of others" (Monastersky, 2005, p. A1). Although some people display opposite traits, in general, Baron-Cohen believed that clear biological differences exist and "boys tend to exhibit preferences that coincide, later in life, with careers in mathematics, science, and engineering" (Monastersky, 2005, p. A1).

While there is a great deal of support for the idea of biological differences between males and females, many experts still question this and prefer to support that there are no differences biologically between the genders that account for the disparity in mathematical achievement. For instance, Yu Xie, University of Michigan at Ann Arbor sociologist, explained that while his work with Kimberlee A. Shauman, a University of California at Davis sociologist, indicated more boys than girls scored in the highest and lowest percentiles of mathematical achievement tests, the ways to explain such occurrences are still unknown (Fogg, 2005). He went on to explain that it is just too early to say that such observed differences are due to nature or biology (Fogg, 2005). He supported his statement by clarifying that "most genetic tests of ability, which are performed on identical twins who are of the same sex, do not take gender into account" (Fogg, 2005, p. A12) and therefore there is not enough evidence to say that there is an innate ability. In addition, Xie claimed that genetic factors cannot account for the increased participation of women in these areas over the past few decades because the genetic pool has not changed during this short period of time (Fogg, 2005). In addition, some experts believe evolution cannot explain the differences between genders since the studying of advanced mathematics and science are modern activities and, therefore, not direct indications of the history of the human species (Halpern et al., 2007).

Furthermore, dismissal of the idea that biological differences between the genders can explain the disparities in the area of mathematics comes from many recent studies that do not support the idea. Many researchers study newborns because they "have had fewer social interaction, so the earlier that sex differences are reliably found, the more likely they may be assumed to be biological in origin" (Halpern et al., 2007, p. 6). However, in several recent studies that examined newborns it was found that across a variety of tasks, "boys and girls develop early cognitive skills relating to quantitative thinking and knowledge of objects in the environment equally well" (Halpern et al., 2007). Michele Mazzocco, director of the Math Skills Development Project at the Kennedy Krieger Institute, supported the argument that biological differences cannot account for mathematical disparities between the genders (Fogg, 2005). Studying students from kindergarten through fifth grade, Mazzocco's research showed minimal to no gender differences in mathematics and spatial skills and she believed that Harvard's president generalized research in a careless manner (Fogg, 2005). Similarly, recent studies of the brain disproved the idea that brain size can predict intellectual performance, at one time used to support the idea that men were intellectually superior to women (Ripley, 2005). In addition, while analyzing brain scans of college students completing an IQ test, it was found that "the parts of the brain that are related to intelligence are different in men and women" (Ripley, 2005, p. 54) but the researchers are unsure of what the different brain structures mean. Hence, they cannot conclude if one is superior over another in the study of mathematics (Ripley, 2005).

In his research, Xie explained that Harvard's president incorrectly inferred "that the underrepresentation of women in the top ranks of science and math could be due to differences in ability" (Fogg, 2005, p. A12) and incorrectly assumed that the lack of participation in these careers indicated a lack of high achievement. Xie added that research indicates women achieving the highest levels of mathematics are still less likely than men to pursue careers in the areas of mathematics and science (Fogg, 2005). Many recent reports support Xie's statements as well as the idea that women can, and do, succeed in mathematics. For instance, Ripley (2005) stated that while the majority of scientists in the United States are men, this has less to do with differences in biology than with the history of academics. She explained that the balance is slowly shifting since women are pursuing more advanced degrees (Ripley, 2005). Compared to the 1970s when women received only one out of every 10 doctorate degrees in the areas of science and engineering, today, women earn one-third of all doctorates issued in science related fields (Ripley, 2005). In 1996, women earned 37% of the bachelor's degrees in mathematics and by 2004, the number of degrees earned in mathematics by women rose to 42% (Halpern et al., 2007). On top of the degrees earned, it has also been reported that "females receive higher grades in school in every subject, including mathematics and science, so the question is not whether females can learn advanced concepts in mathematics and science; class grades show that they can and do" (Halpern et al., 2007, pp. 3-4).

Researchers, who feel that there is not enough evidence to support the claim that innate abilities create the difference between men and women when it comes to the area of mathematics, have numerous explanations for what currently creates the disparity between the genders. Some researchers believe that males and females have different interests that influence them to pursue different careers rather than innate abilities limiting or supporting specific areas of study (Sax, 1996). In several studies, females, at various ages, were able to recognize faces with more accuracy than their male counterparts at the same ages (Halpern et al., 2007). Such findings may provide the necessary support for the theory "that females are more 'people oriented' than males are and thus choose careers and courses of study, such as teaching and social work, that involve greater social interaction, instead of careers that are more 'thing oriented,' such as physics and engineering" (Halpern et al., 2007, p. 8). Similarly, as previously stated, women often have a greater balance in their mathematical and verbal skills and data from studies examining high-ability students showed that this balance leads them to choose careers in the fields of mathematics and science less often (Halpern et al., 2007). Having an imbalance between these two skill sets, favoring a higher mathematical ability than verbal ability, as often found in males, is one variable that was found significant in one's selection of a mathematical or science career (Halpern et al., 2007). Another study conducted in 1979 examined the indicated majors of college freshman and found that although a majority of males and females showed interest in the science fields prior to beginning college, upon arrival "only 50 percent of the women and 69 percent of the men actually declared a major in a scientific area" (Ware et al., 1985, p. 75). This finding is especially important because "the young women and men in the sample were equally predisposed toward a scientific major, comparable in the high level of aptitude they displayed, and of equivalent academic backgrounds in science and mathematics" (Ware et al., 1985, p. 74). This emphasizes the idea that even when similar in ability, women and men chose different careers. The study concluded by examining the chosen careers of the different genders and found that “men showed a slightly higher need for power, and women showed a slightly higher need for affiliation” (Ware et al., 1985, p. 76). A similar study, examining college freshmen, indicating an interest in science, conducted 15 years later, in 1994, found that “men’s career decisions were more often driven by expected monetary or status rewards, while the career decisions of women were driven by the ‘social good’ of the career choice” (Sax, 1996, p. 5).

Similar results were found when examining the graduate programs women and men enroll in after completing a mathematics or science undergraduate degree. For instance, in a longitudinal study that began in 1985 and examined 12,000 college freshmen for nine years, results indicated that the students who graduated with mathematical or computer science degrees most often pursued graduate studies in the areas of mathematics, computer science, education, or business (Sax, 1996). With a rate of 57.6%, men pursued mathematics or computer science graduate degrees at a greater rate than women who only pursued such degrees 30.6% of the time (Sax, 1996). On the other hand, women, 31.3% of the time, chose the field of education for graduate study while only 5% of men chose graduate education programs (Sax, 1996). The results show that women have the innate ability to succeed in the study of mathematics, as displayed by their attainment of a bachelor’s degree in the area, but often choose to use their knowledge in different careers from those men typically choose to pursue. Men who chose to pursue graduate work outside of the mathematics field did so in order to “occupy positions of status and authority” (Sax, 1996, p. 16) in future careers while women pursued a different field that would allow them to one day "influence social change and make a contribution to society" (Sax, 1996, p. 16).

On the contrary, some experts believe that the differences between men and women in the field of mathematics arise because women do not want to commit the time it requires to succeed in advanced math and therefore pursue other options (Felson & Trudeau, 1991). In the same 2005 speech in which he proposed the idea of different innate abilities, Harvard's then president, Larry Summers, also suggested that "women are unwilling to reduce their time with family to work the long hours required to achieve the status of high-level academic scientists" (Halpern et al., 2007, p. 2). Suggesting that women are not willing to sacrifice having children in order to obtain a high-powered career, some experts support Mr. Summers' statement with their own research findings. It was reported in the 2007 article entitled "The Science of Sex Differences in Science and Mathematics" that intellectually gifted men were more career focused and work longer hours by their mid 30s than women of the same age (Halpern et al., 2007). Unwilling to work long hours, women preferred "a more balanced life approach with regard to career, family, and friends" (Halpern et al., 2007, p. 19). Consequently, "if men remain more career focused and spend more hours working, for whatever the reasons, then, in all likelihood, men will accomplish more than their female counterparts and will likely be seen as more successful in the world of work" (Halpern et al., 2007, p. 19). In addition, the desire to have "children was one factor associated with less engagement in mathematical and science careers for women but not for men" (Halpern et al., 2007, p. 19). The lack of extra effort in the area of mathematics can be found in studies involving high school students as well. Girls participate and succeed in required high school mathematics courses but "are less likely than boys to take pre-calculus, advanced placement calculus, and linear algebra" (Felson & Trudeau, 1991, p. 121) which are often optional courses.

Societal issues and stereotyping are additional explanations given for what creates the current disparity between the genders by those who do not believe in different innate abilities. Psychologists, supporting the social cognitive theory, have been "emphasizing the principle that human behavior adapts to the context in which it develops" (Halpern et al., 2007, p. 24) and suggest that "the requirements of modern living may play a greater role in understanding how females and males develop their cognitive abilities" (Halpern et al., 2007, p. 24). "According to social cognitive theory, people are more likely to perform tasks they believe they are capable of accomplishing and are less likely to engage in tasks in which they feel less competent" (Zeldin & Pajares, 2000, p. 2). Hence, the one idea central to this theory is the importance of self-efficacy within individuals. Messages directed toward an individual as well as the society that surrounds an individual can influence personal efficacy and ultimately affect one's effort and persistence required to succeed in difficult tasks (Zeldin & Pajaras, 2000). The brain "is vulnerable to the power of suggestion" (Ripley, 2005, p. 59) and the messages as well as societal issues affecting the self-efficacy of girls in their study of mathematics often come from such sources as school, parents, and cultural stereotypes (Zeldin & Pajaras, 2000).

The school environment often provides various messages to females that can affect their self-efficacy in the area of mathematics. For instance, researchers have hypothesized that "girls are taught that they have low aptitude for mathematics and that they will not need skills in advanced mathematics as adults" (Felson & Trudeau, 1991, p.

113), which cause many "girls to lose interest in mathematics and to lack confidence in their mathematical ability" (Felson & Trudeau, 1991, p. 113). This message is delivered in numerous ways within the school environment. Studies found that within "science and mathematics classes, teachers are more likely to encourage boys to ask questions and to explain concepts" (Halpern et al., 2007, p. 33). A separate study found that 63% of teachers surveyed "believed boys were naturally better in math than were girls" (Brown & Josephs, 1999, p. 246) and while some believed that girls and boys were equally talented in mathematics, none of the teachers surveyed believed that girls were naturally better than boys in the subject (Brown & Josephs, 1999).

If girls continue to show interest into the post-secondary level of education they must often overcome additional obstacles in order to obtain a degree in the area of mathematics or science. "Women are underrepresented on university faculties, particularly in the sciences and quantitative fields, and many worry about the lack of potential role models for female undergraduates" (Bettinger & Long, 2005, p. 152) especially in fields like mathematics where less than one-third of the faculty were female (Bettinger & Long, 2005). In one study examining the effect of faculty gender on females' choices in taking courses and choosing majors, it was found that "female faculty members do have the potential to increase student interest in a subject as measured by course selection and major choice" (Bettinger & Long, 2005, p. 156). This directly applies to the area of mathematics as shown with positive and strong results in such studies (Bettinger & Long, 2005). Another challenge often found at the post-secondary level for women pursuing a degree in the area of mathematics or science is the teaching style often used at the university level. "Teaching practices in the sciences alienate many students, and women in particular, by encouraging competition, reinforcing the notion of science as 'unconnected' to social concerns, and portraying science careers as lonely and excessively demanding" (Sax, 1996, p. 4). Professors in the sciences "are also much less likely to employ teaching styles preferred by women, such as class discussions, cooperative learning techniques, and student selected topics" (Sax, 1996, p. 4). Hence, it is a possibility that women who want to pursue such areas of study may be discouraged by the teaching styles.

The issue of anxiety is also a noted additional challenge women in the science fields must overcome. Math anxiety, often caused by low self-efficacy, was found to hinder women from participating in the area (Chang, 2002). Research showed that women's perceptions of their mathematical abilities are significantly lower than the perceptions of men in the area of mathematics and even when just as competent; women pursue mathematics careers at a lower rate because of low self-efficacy issues (Zeldin & Pajares, 2000). The decrease in self-efficacy often leads to increased anxiety in the area of mathematics and "is the most influential predictor of math test performance, which, in turn, predicts women's entry into science fields" (Sax, 1996, p. 3). A study that took place for three years in the mid 1980s at Barnard College, a women's college, showed "a strong association between math attitudes and openness to scientific careers" (Chipman, Krantz, & Silver, 1992, p. 292). Questionnaires administered to all incoming students found a mathematics attitude score using a set of selected questions that measured each individual's mathematics anxiety or confidence level (Chipman et al., 1992). This score was then used in order to study the association between the students' attitudes towards mathematics and their career goals (Chipman et al., 1992). The study found that the greater a woman's math anxiety level is, the less open she will be to pursuing a career that uses mathematical skills (Chipman et al., 1992). Women who do choose to pursue mathematics and science degrees and careers often "feel they must do better than their male counterparts in order to be considered equal" (Ware et al., 1985, p. 79). This extra pressure to "demonstrate their worthiness through superior competence before being accepted or taken seriously" (Ware et al., 1985, p. 79) can cause some women to experience anxiety as well as discouragement which can ultimately lead them to pursuing other majors or careers.

Parents are another source often found to provide various messages to females that can affect their self-efficacy in the area of mathematics. For instance, one study found that "parents of boys are more likely than parents of girls to think that mathematics is more important than other subjects for their child" (Felson & Trudeau, 1991, p. 114). Similarly, a different study reported that parents "believed mathematics to be more difficult for their daughters than for their sons" (Brown & Josephs, 1999, p. 246). In yet another study, performed in 1988, it was "found that, in general, parents tend to discourage their daughters from quantitative fields of study" (Sax, 1996, pp. 3-4). It should come as no surprise that young women are less confident in their mathematical abilities and therefore often avoid the subject of mathematics when parental support comes in the previous form (Brown & Josephs, 1999).

The last source, most often proposed as providing various messages to females that can affect their self-efficacy in the area of mathematics, is cultural stereotypes that often lead to discrimination. Due to the fact that "women in the United States live with the stereotype that women are bad at math, this gender-specific stereotype might cause women to be concerned about the possibility of confirming their group's negative stereotype" (Brown & Josephs, 1999, p. 247). Research on this idea found that when women internalize social stereotypes and are placed under high-stereotype-threat conditions their "ability to formulate problem-solving strategies is reduced" (Halpern et al., 2007, p. 34) whereas under low-stereotype-threat conditions their ability to problem solve remains high (Halpern et al., 2007). The stereotype that men are better at mathematics than women has led many researchers to study the discrimination within this field of study. It has been found by social scientists "that changing a female name to a male name on otherwise identical work increases its perceived value" ("Separating science from stereotype", 2005, p. 253). It has also been noted that females, in the past, scored higher on the verbal section of the SAT "until male test scores were raised by selective inclusion of questions on which males performed better, such as those on politics, business and sports" ("Separating science from stereotype", 2005, p. 253). However, "no similar attempt has been made to 'balance' the math section of the SAT" ("Separating science from stereotype", 2005, p. 253) in order to help raise the scores of female test takers. This is in addition to the fact that "the SAT tends to underpredict female and overpredict male academic performance" ("Separating science from stereotype", 2005, p. 253). Whether it is that "women are taught to view mathematics through socialization practices that place mathematics-relevant tasks in a male domain" (Zeldin & Pajares, 2000, p. 3) or the fact that "men and women have different sex-typed experiences in childhood" (Zeldin & Pajares, 2000, p. 3), the discrimination some women in the field of mathematics have encountered makes them wonder if they made the wrong decision in pursuing the area (Monastersky, 2005). Alice Silverberg, a Harvard alumni and professor of mathematics at the University of California at Irvine, stated

> I no longer ask why there are so few women in mathematics; I ask why there are so many. I can think of few male mathematicians who would have stayed in the field if they had faced the prejudice and discrimination female mathematicians deal with. (Monastersky, 2005, p. A1)

Despite the previous findings, some researchers, especially those who support the idea of biological gender differences, do not support the idea that societal issues and stereotyping are creating the current disparity between the genders in the fields of mathematics and science. Some researchers argue that evidence is not available "that boys are more likely to be encouraged by their parents to take advanced mathematics. Nor is there evidence for gender effects on the attributions of ability made by parents" (Felson & Trudeau, 1991, p. 121). In addition, when it comes to the issue of available female role models, it has been found, from a study conducted through personal interviews with women mathematicians, that women who pursued and obtained their degrees "did not recall or require exclusively female role models" (Zeldin & Pajares, 2000, p. 15). Instead, "they found critical male influences along the way, and these male influences had pronounced effects on their confidence" (Zeldin & Pajares, 2000, p. 15). Several researchers have also opposed the aspect of mathematics anxiety in females. Research has found that girls experience more anxiety about school and tests in general and therefore, anxiety is not directed specifically to mathematics (Felson & Trudeau, 1991). It was also shown that girls devote more time and effort to the area of mathematics than do boys (Felson & Trudeau, 1991). With respect to the previous findings, researchers argued that "if girls are taught that they lack ability in mathematics or that mathematics is a male domain, they should exert less effort and experience more anxiety about mathematics than about other subjects" (Felson & Trudeau, 1991, p. 123). However, this is not the case and hence, they claim, that "neither effort nor math anxiety can help to explain why girls earn worse grades in mathematics than in their other subjects" (Felson & Trudeau, 1991, p. 121). Some researchers dispute the idea that boys and girls are socialized differently and girls must overcome stereotypes, which ultimately affect their mathematical achievement. According to the standard socialization model, the gender effect of societal influences should be uniform (Felson & Trudeau, 1991). That is, if females are affected by the stereotypes that surround the area of mathematics, then this socialization of attitudes should affect the performance of females on all types of mathematical assessments especially as ages and social pressures raise (Felson & Trudeau, 1991). However, females outperform males on various mathematical assessments at various ages, which suggest that gender differences in mathematics cannot be accredited to societal stereotypes (Felson & Trudeau, 1991).

As varied as the explanations are for why differences between the genders exist in the area of mathematics, so too are the proposed solutions by the different sides of this debate. As an addition to the Higher Education Act, Title IX passed in 1972 in order to help women obtain "equal educational opportunity at institutions accepting federal educational dollars" (Fields, 2005, p. 9). Even with this law in place, those who believe women are just as able to succeed in the fields of mathematics and science want to see more done to help women advance in such areas of study and professions. Beginning with the elementary and secondary levels, researchers suggest using single-gender classrooms in order to teach boys and girls more effectively (Ripley, 2005). Findings suggest that different areas of the brain mature at different ages and rates in the genders, hence, teaching in coed classrooms often results in students being required to perform tasks that are not developmentally appropriate for their age or gender (Ripley, 2005). The method of coed teaching has caused many students to become reluctant to pursue different subject areas because they have failed at portions of them in the past (Ripley, 2005). This failure is not because they cannot do it but rather it is because they have not been taught in the correct manner (Ripley, 2005). Beyond single gender classrooms, researchers have stated the need for higher education institutions to collaborate with elementary and secondary schools in order to strengthen the mathematics and science programs so students' interest can develop (Chang, 2002). Researchers have also stated the need to increase the self-efficacy of girls in the area of mathematics from very early on in their education. It was stated in the article entitled "Against The Odds: Self-Efficacy Beliefs Of Women In Mathematical, Scientific, and Technological Careers" by Zeldin and Pajares (2000) that

> Girls will develop higher mathematics self-efficacy in homes and classrooms in which parents and teachers stress the importance and value of mathematical skills, encourage girls to persist and persevere in the face of academic and social obstacles, break down stereotypical conceptions regarding academic domains, convey the message that success in an academic area is a matter of desire, effort, and commitment rather than of gender or established social structure, and provide models that verify that message. (Zeldin & Pajares, 2000, p. 16)

At the post-secondary level, researchers suggest the need for additional role models. Many government agencies, companies, and universities have been working to increase the representation of women in male-dominated areas and have begun programs to help women succeed in such fields (Bettinger & Long, 2005). The National Science Foundation has created its ADVANCE program that encourages universities to increase the number of faculty members who are women (Bettinger & Long, 2005). Researchers also express the need for post-secondary programs to reduce the anxiety and improve the confidence levels of women in the areas of mathematics and science (Chipman et al., 1992). Many believe that correcting misconceptions and helping “students to develop an accurate picture of their abilities” (Ware et al., 1985, p. 81) could “prevent them from becoming prematurely and unnecessarily discouraged” (Ware et al., 1985, p. 81). Designing strategies to overcome anxiety and to reduce the effects of stereotypes could influence many women to stay in the areas of mathematics and science throughout college (Brown & Josephs, 1999). Findings suggest that such interventions should be taken during the freshman year of post-secondary education since that is the time when most women tend to leave the programs in order to pursue other opportunities (Ware et al., 1985).

Researchers who support the idea of biological differences between the genders have their own suggestions. Backed by results of their research, they suggest keeping coed classes and teaching spatial reasoning at the elementary and secondary levels. It has been found that throughout the decades when single-gender schools decreased, females achieved in all subjects within school and began attending post-secondary institutions at greater rates than their male counterparts (Halpern et al., 2007). Hence, experts suggest that these results do not support the idea of single-gender classrooms or schools. Researchers have also found that boys, from early on in life, develop spatial abilities through their methods of playing that gives them an advantage at mathematics, based primarily on such skills (Monastersky, 2005). Suggested and supported by such organizations as the National Science Foundation, the curriculum and instruction at the elementary level as well as at the secondary level should help develop spatial skills in order to improve girls' spatial abilities to help close the mathematical achievement gap (Monastersky, 2005). At the post-secondary level, it has been suggested that educators should change women's views on predominately-male careers by emphasizing how such areas of study can be used to help people as well as allowing women to take elective courses within these areas of study in order to satisfy their broader interests (Monastersky, 2005). Despite these proposed solutions, some experts still believe that the nation needs to stop worrying about closing the discrepancies in these careers and allow students to choose their area of study and career based on their interests (Monastersky, 2005). The United States prides itself on providing opportunities to all citizens and permitting them to choose their own direction in life but the attempt to push women into certain careers just so that there can be an equal representation of the genders goes against this philosophy the country was built upon (Monastersky, 2005).

In summary, there is disagreement about whether or not biological differences account for mathematical disparities between the genders. Those who believe that women are just as able as men at mathematical tasks, have a variety of explanations, ranging from cultural stereotypes to a lack of role models within the fields, for what may be causing the differences in the numbers of women and men who pursue careers in mathematics or science (Zeldin & Pajares, 2000). Both sides of this debate support their views with research and suggest possible solutions to fix the current situation we are facing as a nation.

The Participation of Minorities in Mathematics

Beyond the lack of females, the participation of few minorities in the area of mathematics has been at the forefront of discussion for many researchers as well. A growing concern has risen, that without participation from individuals of ethnic minority groups, the United States may not be able to stay the leader in technical and scientific fields (Kennedy & Schumacher, 2005). According to "statistical data obtained from the College Board reports concerning the performance of women and minorities in high school mathematics and intended college majors" (Kennedy & Schumacher, 2005, p. 189), the disparity in the area of mathematics begins to appear as early as high school. For instance, it was found that with the exception of Asian Americans of whom "42% took calculus, the other ethnic minorities lag somewhat behind Whites, particularly with respect to having taken calculus" (Kennedy & Schumacher, 2005, p. 189). It was reported that "whereas 26% of the White students reported having taken calculus, only 14% of the African Americans and between 14% and 19% of students from other ethnic minority groups reported having taken calculus" (Kennedy & Schumacher, 2005, pp. 189-190).

In addition to course enrollment patterns, the disparities in the area of mathematics have also been evident in achievement scores as well as in the "allocation of human and material resources" (Bol & Berry, 2005, p. 32). Despite showing substantial improvement during the 1970s and the beginning of the 1980s, "minority students, particularly Black and Hispanic students, typically score below their White peers in all mathematics content areas" (Bol & Berry, 2005, p. 33) according to the mathematics portion of recent National Assessment of Educational Progress (NAEP) reports. The widening gap between the ethnicities has been explained as, "students who have access to advance mathematics courses, taught by a highly qualified teacher (human resource), and who have access to adequate material resources," (Bol & Berry, 2005, pp. 32-33) will have greater achievement in mathematics than peers who lack such resources. Consequently, achievement in the area of mathematics is also highly correlated with a student's socioeconomic status, which is "typically defined by family income, level of poverty in the child's neighborhood, and educational attainment by parents" (Jordan & Levine, 2009, p. 60). It has been found that "minority children, such as African American, Hispanic, and Native American children, are disproportionately represented in low-income populations, resulting in significant racial and social-class disparities in mathematics learning" (Jordan & Levine, 2009, p. 60) due to the lack of necessary resources found in these underfunded schools (Jordan & Levine, 2009).

Beyond socioeconomic status and available resources, there are many reasons given by researchers for the achievement gap in mathematics between different ethnicities. Low engagement is one possible reason for the achievement gap (Uekawa, Borman, & Lee, 2007). It has been stated that "teachers use the antithesis of constructivist principals when working with minority students: more teacher-directed instruction and less student-led exploration, little cooperative and peer-supported learning, and more structured, lecture-style presentations" (Jamar & Pitts, 2005, p. 129). A study conducted in 2007 examined the daily classroom processes and student engagement of high school math classes in four cities in the United States (Uekawa et al., 2007). It was found, through the use of student surveys and researcher observations, that Asian American students preferred independent work rather than group work where as Latino and White students responded “well to group work and negatively to seatwork” (Uekawa et al., 2007, p. 32). Additionally, it indicated that “Black students seemed less affected by changes in classroom activities and were generally highly engaged in all circumstances” (Uekawa et al., 2007, p. 32) and White students generally favored teachers lecturing rather than individual seatwork (Uekawa et al., 2007). While it was found that students of different ethnicities have different preferences in the teaching style, it was argued by some researchers that the school environment, in general, is “hostile to historically underserved students because mainstream, traditionally organized schools and classrooms do not acknowledge or take into account the cultural orientations of these students” (Uekawa et al., 2007, p. 7). Whether or not teachers are acknowledging cultural differences, the key to closing the achievement gap in the area of mathematics requires students to be engaged in the material because “engaged students pay close attention to ongoing classroom activities, are interested in the content of classroom lessons, and may also experience heightened states of awareness, confidence, and performance” (Uekawa et al., 2007, p. 7).

Teacher perceptions and academic rigor are also commonly stated as possible explanations for the current mathematics achievement gap. For instance, in the 2005 article entitled “Secondary Mathematics Teachers’ Perceptions of the Achievement Gap”, middle school and high school teachers, along with university faculty, belonging to the National Council of Teachers of Mathematics (NCTM) reported their perceptions of the current achievement gap. "Given that teachers' beliefs, expectations, instructional practices, and professional development activities influence their students' achievement," (Bol & Berry, 2005, p. 36) the researchers believed that by eliciting the teachers' views, "strategies for alleviating the achievement gap in mathematics" (Bol & Berry, 2005, p. 36) could be found. Results from the study indicated, "teachers are more likely to attribute the achievement gap to students' characteristics, whereas supervisors and university faculty are more likely to attribute the gap to differences in the exposure or access to quality curriculum and instruction" (Bol & Berry, 2005, p. 41). Teachers who attribute the gap to student characteristics such as "motivational levels, work ethic, and family or parent support," (Bol & Berry, 2005, p. 40) may be less likely to "modify their instructional practices to better align with NCTM standards and principles" (Bol & Berry, 2005, p. 41) which could ultimately be supporting and increasing the gap. "The lower mathematics achievement levels of minority students, particularly Black students, may be indicative of the curriculum and instruction that those students receive" (Bol & Berry, 2005, p. 33). This is especially significant when considering that "approximately 33% of high school mathematics students in high minority schools and 30% of high school mathematics students in high poverty schools are taught by teachers without a teaching license or a major in mathematics" (Bol & Berry, 2005, pp. 33-34). "Despite massive attempts at school reform and restructuring, teacher ideologies and beliefs often remain unchanged" (Jamar & Pitts, 2005, p. 129) which hinders change from occurring "if perceptions of students' abilities do not coincide with the purposes of initiatives to improve the performance of minority students" (Jamar & Pitts, 2005, p. 129).

Similarly, academic rigor has also been the focus of several studies, as a possible reason for the achievement gap. As early as the late 1970s, studies found that "high school students' 'academic resources' are much stronger predictors of educational outcomes than are social background factors including gender, race, and socioeconomic status" (Horn, Kojaku, & Carroll, 2001, p. 1). The August 2001 "Statistical Analysis Report" by the National Center for Education Statistics analyzed the issue of high school academic rigor. Using data from the 1995-96 national longitudinal Beginning Postsecondary Students Survey data set, the high school mathematics curriculum was separated into "three levels of coursetaking: (1) Core curriculum or below, (2) mid-level, and (3) rigorous" (Horn et al., 2001, p. iii). The lowest coursetaking level included three years of mathematics at the secondary level whereas the rigorous level required that students take four years of mathematics including a pre-calculus class or higher (Horn et al., 2001). Students at the mid-level had curriculum requirements between the two other levels and were to have taken at least algebra I and geometry (Horn et al., 2001). "The level of high school academic curriculum completed by beginning 4-year college students was associated with their demographic and socioeconomic characteristics and also with the economic status of the student body in their high schools" (Horn et al., 2001, p. iii). Consequently, students from more advantaged areas reported completing a rigorous high school mathematics curriculum at a greater rate than did students who came from low-income households or attended schools within a high poverty community (Horn et al., 2001). Reports also found racial and ethnic group differences within these disparities. For instance,

> Black students were much less likely than either White or Asian/Pacific Islander students to complete rigorous curricula (8 percent versus 20 and 31 percent, respectively) and more likely to complete programs no higher than the core curriculum (42 percent versus 29 and 27 percent). Asian/Pacific Islander students were the most likely to complete rigorous curricula (31 percent). (Horn et al., 2001, pp. iii-iv)

Such disparities at the high school level continue to affect students at the post-secondary level. "After controlling for demographic characteristics, high school socioeconomic status, SAT scores, and other related variables, students who completed rigorous high school academic curricula … were more likely to stay on track to a bachelor's degree than their counterparts who completed no higher than core curricula" (Horn et al., 2001, pp. 29-30). In a separate study, conducted using data from the Florida Longitudinal Education and Employment Dataset, it was found that of the students pursuing degrees in the areas of science, technology, engineering, and mathematics (STEM), "Hispanic and Asian students are significantly more likely than White students to obtain a STEM degree, and Black students are not significantly different from White students" (Tyson, Lee, Borman, & Hanson, 2007, p. 267). While it was found that "Black and Hispanic students complete lower level high school courses," (Tyson et al., 2007, p. 243) "Black and Hispanic students who did take high-level courses are as likely as White students to pursue STEM degrees" (Tyson et al., 2007, p. 243). The findings led researchers to conclude that "high school is a primary point for Black and Hispanic students to drop off STEM pathways because they do not take high-level courses at the same rate as their peers" (Tyson et al., 2007, p. 265) "but these racial disparities may not have a strong influence in college among talented Black and Hispanic students" (Tyson et al., 2007, p. 260).

Also labeled as a possible explanation for the achievement gap, is the area of early mathematics foundations influenced by early experiences and instruction. For instance, the 2009 article entitled "Socioeconomic Variation, Number Competence, and Mathematics Learning Difficulties in Young Children," examined the issue of "delays or deficiencies in number competencies exhibited by low-income children entering school" (Jordan & Levine, 2009, p. 60). Most children who experience "mathematics difficulties in first grade and later, seem to have particular problems with the verbal or symbolic systems of number, which are heavily influenced by early experiences and instruction" (Jordan & Levine, 2009, p. 62). Furthermore, students from low-socioeconomic "backgrounds, who tend to have both mathematics and reading difficulties, are at particular risk for experiencing persistent mathematics difficulties" (Jordan & Levine, 2009, p. 63). In addition, children from low-income communities "enter kindergarten well behind their middle-income peers on tasks assessing number competence" (Jordan & Levine, 2009, p. 63) as well as tasks assessing numerical operations (Jordan & Levine, 2009). To make matters worse, such low-income students often receive less support at home to help them in the area of mathematics (Jordan & Levine, 2009) and "public preschool programs serving children from low-income families provide fewer learning opportunities and supports for mathematical development than ones serving middle-income families" (Jordan & Levine, 2009, p. 65).

A separate but similar report entitled "Minority Students in Mathematics: The Reading Skills Connection" examined the connection between reading performance and mathematics achievement as well as the connection between gender and ethnicity on academic achievement. The researcher's goal was to further the "understanding of the type of academic preparation occurring among pre-college students from minority backgrounds" (Kickbusch, 1985, p. 402). A study of more than 1,000 students and data from the mathematics portion of various achievement tests, such as the Stanford Achievement Test (SAT) and Comprehensive Test of Basic Skills (CTBS), found that "on mathematics total score, non-minority females ranked first, non-minority males second, minority males third, and minority females fourth" (Kickbusch, 1985, p. 409). The results also concluded that "in general, students had higher ranks on the computational subtest than on the concepts subtest" (Kickbusch, 1985, p. 409). In addition, "while non-minority students tended to do as well on application as on concepts, minority students did worse on the latter than on the former" (Kickbusch, 1985, p. 410) which suggests "that minority students, even more than non-minority ones, have particular difficulty with the concepts in and application of mathematics" (Kickbusch, 1985, p. 410). The study also found a relationship between a student's performance in reading and his or her corresponding performance in mathematics (Kickbusch, 1985). Strong relationships were found between reading comprehension and the understanding of mathematical concepts as well as between reading comprehension and the application of mathematical concepts (Kickbusch, 1985).

Lastly, the areas of cultural differences and immigration were examined as possible explanations for the differences in mathematics achievement. "Understanding cultural differences between social classes provides some clues to why there are persistent mathematics achievement disparities and why low-income children may be less responsive to reforms in mathematics education recommended by the National Council for Teachers of Mathematics" (Jordan & Levine, 2009, p. 65). Just as students from various backgrounds have preferences towards different instruction methods, it has also been stated, "children from lower-income families may have different cultural beliefs about mathematics than their higher-income counterparts" (Jordan & Levine, 2009, p. 65). Tseng (2006) stated that

> understanding how immigration matters is increasingly important, given the changing demography of the United States. Children of immigrants now constitute 20% of the U.S. population; their numbers are growing seven times faster than that for children of U.S.-born parents; and 85% of children of immigrants are from Asia, the Pacific Islands, Latin America, the Caribbean, and Africa, and face experiences as racial minorities in the United States. (Tseng, 2006, p. 1434)

Within her 2006 study that sought "to unpack the immigration-related factors associated with youths' educational choices during the transition to college and adulthood" (Tseng, 2006, p. 1434), Tseng found generational differences in educational choices. Using surveys and obtained school records of students from various backgrounds, findings suggest that "children of immigrants chose courses of study with higher math and science content than that of their peers with U.S.-born parents" (Tseng, 2006, p. 1434). The decision to major in a quantitative area such as mathematics may be in part to the students' perception of their verbal abilities (Tseng, 2006) as well as the finding that suggests, "that children of immigrants have higher academic motivation and educational, social, and economic aspirations than do their peers from U.S.-born families" (Tseng, 2006, p. 1444). It has also been stated, "immigrants are drawn to math and science fields because they are in high demand in the economy and bear the promise of high status and well-paying occupations" (Tseng, 2006, p. 1435).

In an effort to examine student interest and perseverance in mathematics, "local, state, and national attention is being given to performance in mathematics at the pre-college level" (Kickbusch, 1985, p. 403). Many programs like that of the Math Accelerating Professionals Program have been developed to encourage "collaboration of university math professors, business professionals, and high school math teachers" (Kennedy & Schumacher, 2005, p. 190) with the hope of improving minority performance in the area of mathematics as well as to increase student interest overall in the field of mathematics (Kennedy & Schumacher, 2005). However, researchers examining the current minority achievement gap in mathematics offered a variety of additional solutions they believe could possibly close the present gap. Surveyed secondary mathematics teachers recommended the grouping of "students into homogenous ability groups, which is reminiscent of tracking" (Bol & Berry, 2005, p. 41) as well as teacher professional development in order to improve "knowledge of mathematics content, pedagogy, and diverse learners, including English language learners" (Bol & Berry, 2005, p. 41). Many believe that "reducing misconceptions or focusing on strategies under educators' control would represent a first step in reducing the achievement gap" (Bol & Berry, 2005, p. 42). Another suggestion was the creation of early intervention programs that provide mathematics foundations for all students (Jordan & Levine, 2009). Additionally, "it is critically important that schools find ways to offer opportunities for all students to enroll in the highest level courses in mathematics"

(Tyson et al., 2007, p. 269) even if that means encouraging “students to enroll at neighboring community colleges to complete such courses” (Tyson et al., 2007, p. 269). In addition, the current policy debates on the issue of immigration often overlook the fact that it may be such “children who make the most profound contributions to our nation’s economy and our 21st –century needs for a highly educated workforce in technology and science” (Tseng, 2006, p. 1444).

The reasons stated by researchers as possible causes for the current achievement gap in the area of mathematics are numerous as are the suggested solutions for how to end the problem. Numerous data sets and analysis techniques have been examined in an attempt to solve the current problem facing the nation but the debate surrounding the causes and potential solutions are still in deliberation among educational researchers (Tyson et al., 2007).

Summary

In summary, while the curriculums of Catholic, independent, and public high schools have become very similar over the years, the debate about which sector provides the best achievement in the area of mathematics continue. The issue of low female and minority representation in the field at the post-secondary level of education also has numerous researchers suggesting various potential causes and possible solutions (Kennedy & Schumacher, 2005). Despite a thorough literature review, there was no evidence found of studies that attempt to answer the question about who math majors are at the post-secondary level of education or their demographic backgrounds. Therefore, it seems evident that this study will help to close the gap in the literature currently available and provide explanation as to which high school sector generates a greater proportion of students who pursue the area of mathematics.

Chapter 3-Methodology

This causal-comparative study analyzed the proportions of students pursuing the area of mathematics in education when compared by the type of high school they attended, namely public, Catholic, or other independent private. The purpose was to determine if different school sectors produce a greater proportion of mathematics majors in post-secondary education as well as to identify potential predictors of mathematics majors in post-secondary education.

Data Collection and Analysis

The data from the United States Department of Education was analyzed to determine if there have been significant differences between the proportions of students who major in mathematics at the post-secondary level when compared by the type of high school the students attended. Analysis of two separate national longitudinal studies was conducted in order to address the hypotheses. The first study obtained from the NCES that was examined is the NELS: 88. According to the NCES, this study was

> initiated in 1988 with a cohort of eighth-graders. These students were then resurveyed through four follow-ups in 1990, 1992, 1994, and 2000. On the questionnaires, students reported on a range of topics including: school, work, and home experiences; educational resources and support; the role in education of their parents and peers; neighborhood characteristics; educational and occupational aspirations; and other student perceptions. For the three in-school waves of data collection (when most were eighth-graders, sophomores, or seniors), achievement tests in reading, social studies, mathematics and science were also administered. To further enrich the data, students' teachers, parents,

> and school administrators were also surveyed. Coursework and grades from students' high school and postsecondary transcripts were also collected. (National Center for Education Statistics, n.d., para. 1-2)

The collection of the NELS: 88 data set began in the spring of 1988 when “NCES initiated a longitudinal study of 8th-grade students attending 1,052 high schools across the fifty states and the District of Columbia” (Curtin, Ingels, Wu, Heuer, & Owings, 2002a, p. 15). Over the next 12 years, a subset of these original students was continually surveyed in the four follow-up studies, “along with additional individuals who helped to form representative 10th- and 12th-grade cohorts” (Curtin et al., 2002a, p. 15). “In total, almost 11,000 pieces of information were collected on a large segment (approximately 12,000) of the original sample of approximately 25,000 students” (Curtin et al, 2002a, p. 15).

The second study that was examined is the ELS: 2002. According to the NCES, ELS: 2002,

> the most recent secondary school longitudinal survey conducted by the National Center for Educational Statistics (NCES), tracks the educational and developmental experiences of a nationally representative sample of students in public and private high schools in the United States. Since the base-year interview in 2002, sample members have participated in two follow-up surveys: the first follow-up took place in the spring of 2004 when most student participants were high school seniors, and the second follow-up took place in 2006 when most were 2 years out of high school. Second follow-up data include information related to

postsecondary education, labor force participation, family life, and civic engagement. (Bozick & Lauff, 2007, p. 1)

In the spring of 2002, "the base-year interview was carried out in a nationally representative probability sample of about 750 public, Catholic, and other private schools" (Bozick & Lauff, 2007, p. 1) which included about 15,400 high school sophomores from the approximate 17,600 eligible sophomores (Bozick & Lauff, 2007). Approximately 15,000 students participated in each of the two follow-up studies that were conducted to date (Bozick & Lauff, 2007) and high school transcripts were collected for approximately 15,000 student participants between the two follow-up interview sessions conducted (Bozick & Lauff, 2007).

The aforementioned two data sets were used to identify whether there were significant proportional differences in the types of students pursuing mathematics from the various high school sectors as well as possible predictors of mathematics majors in post-secondary education. The identification of such differences and predictors may help in understanding what type of students become mathematics majors, including the types of high school they attended and their ethnicities, which may provide some insight into which students are becoming interested in these areas during their high school experience, and the groups on which educators need to focus their attention. The results of this study can help educators develop programs at both secondary and post-secondary schools to help increase student interest in mathematics in groups, typically underrepresented in the field of mathematics.

Research Questions and Hypotheses.

The following questions addressed in this study were:

1. Are there significant differences between the proportions of students pursuing the area of mathematics when compared by the type of high school they attended, namely public, Catholic, or other independent private?
2. Are there significant differences between the proportions of students pursuing the area of mathematics when compared by type of high school they attended and when further separated according to gender and ethnicity?
3. Are there predictors of mathematics majors in post-secondary education?

The following hypotheses proposed in relation to the above questions were

1. There will be significant differences between the proportions of students pursuing the area of mathematics when compared by the type of high school they attended, namely public, Catholic, or other independent private.
2. There will be significant differences between the proportions of students pursuing the area of mathematics when compared by type of high school they attended and when further separated according to gender and ethnicity.
3. There will be several significant predictors of mathematics majors in post-secondary education.

Investigation of the above questions and hypotheses used numerous independent variables. For instance, analysis of the students' reported race, gender, and school sector occurred in the investigation of potential proportional differences. In addition to the previous variables, examination of independent variables including the students' parents' highest level of education, generational status, and school urbanicity served as potential predictors of mathematics majors. All the independent variables in this study helped in the examination of the dependent variable of this study, which were the students' majors pursued at the post-secondary level of education, in particular, the area of mathematics. Many statistical strategies were applied in an attempt to answer the research questions. The NELS: 88 data set as well as the ELS: 2002 data set were analyzed to determine if there were significant differences between the proportions of students who major in mathematics at the post-secondary level when compared by the type of high school the students attended, namely public, Catholic, or other private and if there are predictors of post-secondary mathematics majors.

Before analysis can be conducted, an examination of the reliability and validity of each data set must be established. Reliability is defined by the NCES as "the consistency in results of a test or measurement including the tendency of the test or measurement to produce the same results when applied twice to some entity or attribute believed not to have changed in the interval between measurements" (Curtin, Ingels, Wu, & Heuer, 2002b, p. 229). Whereas, validity is defined as "the capacity of an item or measuring instrument to measure what it was designed to measure; stated most often in terms of the correlation between scores in the instrument and measures of performance on some external criterion" (Curtin et al., 2002b, p. 231).

The "*Psychometric Report for the NELS: 88 Base Year Through Second Follow-Up* provides information about test reliability and validity and test specifications" (Curtin et al., 2002b, p. 24) for the NELS: 88 data set. The report states that one of the main objectives, "suggested by the NELS Technical Review Panel (TRP) and/or NCES project staff during the base year development" (Rock & Pollack, 1995, p. 3), was that "reliabilities of the component tests should be psychometrically acceptable for the purpose of measuring individual status as well as growth" (Rock & Pollack, 1995, p. 3).

In addition, it was a stated objective that "the accuracy of measurement, i.e., the standard error of measurement, should be relatively constant across SES, sex and racial/ethnic groups" (Rock & Pollack, 1995, p. 4) and "the NELS: 88 battery was specifically designed to reduce the gap in reliabilities that is typically found between the majority group and the racial/ethnic minority groups" (Rock & Pollack, 1995, p. 4). In order to achieve the reliability objectives previously stated, the NELS: 88 study took precautions including, but not limited to, designing multilevel tests to reduce limitation effects and creating scoring procedures for simplified interpretation from one follow-up to the next.

In terms of validity, an objective calling for "the individual test content areas [to] demonstrate some discriminate validity" (Rock & Pollack, 1995, p. 4) was established and empirical checks on the validity resulted in acceptable results (Rock & Pollack, 1995). In respect to psychometric properties of the NELS: 88 data set, it was stated that

> in the final analysis the reliability and validity of the NELS: 88 cognitive scores depend on the: 1) appropriateness of the test content specifications, 2) psychometric quality of the test items themselves, 3) appropriateness of the difficulty of the tests for the students being measured, 4) lack of speededness, 5) success of the IRT procedures used for linking across grades and forms, and 6) scoring procedures. (Rock & Pollack, 1995, p. 67)

Additional information about the specific details of the NELS: 88 study is found within the NELS: 88 psychometric report by Donald Rock and Judith Pollack.

Examining the validity and reliability of the ELS: 2002 data set, the NCES stated that most of the items used within this study's questionnaires were taken from prior studies such as NELS: 88 and therefore, "given their past use with large, nationally representative samples, their measurement characteristics are well established" (Bozick & Ingels, 2008, p. A-9). Similar precautions were taken in the set-up and design of the ELS: 2002 as were previously discussed in the NELS: 88 reliability and validity examination. For instance, before data collection began, a preliminary "field test (conducted in 2001) evaluated the validity and reliability of several student-based motivational items" (Burns, Heuer, Ingels, Pollack, Pratt, Rock, Rogers, Scott, Siegel, & Stutts, 2003, p. 70) and accommodations were developed to reduce threats to internal validity in such areas as test presentation and response options, test setting, and test timing (Burns et al., 2003). Reliability issues present in the NELS: 88 study were also taken into consideration throughout this study. For example, scoring reliability issues were handled by training test readers to score responses according to established scoring rubrics provided in order for all tests to be evaluated in a consistent manner. In addition, ELS: 2002 utilized "a two-stage test design to maximize the reliability of individual measurement" (Burns et al., 2003, p. 65) and to help reduce limitation effects. "Some questions were asked of both parents and students. This served two purposes, first to assess the reliability of the information collected and second to determine who was the better source for a given data element" (Burns et al., 2003, p. 137). Further analysis of reliability occurred when the investigation of individual items took place to determine its contribution to internal consistency and "if the removal of an item from a scale would increase the scale's internal consistency (reliability), the item was dropped from the scale (and questionnaire)" (Burns et al., 2003, p. 76). Further information on the reliability and validity of the various data collection techniques used to collect the ELS: 2002 data set is available through papers produced on ELS: 2002 by the NCES and private authors.

Therefore, the NCES, in collaboration with the United States Department of Education, has taken into account various threats to the reliability and validity of both the NELS: 88 and ELS: 2002 and made changes or accommodations to reduce such threats.

After extensive literature review, it was decided that proportions would yield the most effective form of data for viewing the differences in mathematics majors produced by the schooling sectors. A greater percentage of students in the United States attend public high schools when compared to the number of students who attend private Catholic or private independent non-Catholic high schools (Lee, Chow-Hoy, Burkam, Geverdt, & Smerdon, 1998). Therefore, comparing the proportions rather than direct numbers will take into account these beginning differences in the attendance numbers by schooling sector.

In order to address the first two proposed hypotheses, this study utilized a series of Fisher's exact tests using proportions in order to analyze the potential differences between school sectors as well as when data is further disaggregated according to variables such as the gender and ethnicity of students. As a form of hypothesis testing which helps a researcher determine just how certain he or she can be that the proposed hypothesis is true, a Fisher's exact test measures the degree of certainty a researcher can have in the truth of the hypothesis about the proportions in question (McDonald, 2009). The Fisher's exact test of independence is "used to determine if there are nonrandom associations between two categorical variables" (Weisstein, 2010, para 1) and "is more accurate than the chi-squared test or [goodness-of-fit test] of independence when the expected numbers are small" (McDonald, 2009, para 1). The usage of this test is appropriate when comparing nominal or ordinal variables from randomly sampled populations (MicrobiologyBytes, 2009). This test is appropriate when the data has been collected using a random sampling procedure, observations are independent, and data values must be mutually exclusive (MicrobiologyBytes, 2009). An examination of the NELS: 88 and ELS: 2002 data sets used in this study indicated the criteria were met and therefore the Fisher's exact test is appropriate.

While calculated direct proportions may initially appear different, a Fisher's exact test, testing the difference between two proportions, allowed a comparison of the proportions of mathematics majors who attended the various high school sectors in order to determine if they are statistically different from one another. Therefore, in addition to the calculated proportions, a discussion of the findings from the Fisher's tests for these first two questions are in terms of p-values and statistical significance. The p-value, short for probability value, uses measurements derived from the sample to create a number between 0 and 1 that measures the plausibility of the null hypotheses, the opposites of the respective proposed research hypotheses (Navidi, 2006). The tests measured "the strength of the disagreement between the sample" (Navidi, 2006, p. 369) collected and the null hypotheses which resulted in p-values. "The smaller the p-value, the stronger the evidence is against [the null hypothesis]" (Navidi, 2006, p. 369). A general rule suggests the rejection of the null hypothesis whenever the calculated p-value is less than or equal to the significance level of .05, which derives from a 95% confidence, meaning there is a 5% chance of accidentally rejecting the null hypothesis when it should not have been rejected (Navidi, 2006). This general rule applied to this study as well. The calculated p-value helped in the determination of statistical significance. "When the null hypothesis is rejected at a specific significance level, it can be concluded that the difference is probably not due to chance and thus is statistically significant" (Bluman, 2009, p. 421). Differences that result in a p-value less than .05 were deemed statistically significant in this study also.

To analyze the data further, in terms of possible predictors of mathematics majors at the post-secondary level, a multiple regression analyzed the predictive nature of numerous independent variables available within the data sets. Table 1 and Table 2 provide the compiled lists of variables factored in the multiple regression analyses. Like a simple linear regression, a multiple regression fits a linear model but relates a dependent variable to several independent variables rather than just a single independent variable (Navidi, 2006). The result of such analysis will be a regression equation and if information about the independent variables is available, the regression equation can then predict the outcome for the dependent variable.

A multiple regression analysis is considered an appropriate technique if the following criteria are met. Variables must be normally distributed meaning that when graphically displayed and numerically tested, a normal distribution must appear to be a valid assumption (Osborne & Waters, 2002). Secondly, there must be a linear relationship between each independent variable and the dependent variable. "Standard multiple regression can only accurately estimate the relationship between dependent and independent variables if the relationships are linear in nature" (Osborne & Waters, 2002, p. 3). Next, researchers must examine variables in order to determine that they are reliable and without error. While effect sizes for variables can be over-estimated if measurements were not collected in a reliable manner, methods for correcting low reliability can be conducted (Osborne & Waters, 2002). It has been argued that "authors should correct for low reliability to obtain a more accurate picture of the 'true' relationship in the population, and, in the case of multiple regression or partial correlation, to avoid over-estimating the effect of another variable" (Osborne & Waters, 2002, p. 3). Lastly, a check of the assumption of homoscedasticity must occur. "Homoscedasticity means that the variance of errors is the same across all levels of the [independent variable]" (Osborne & Waters, 2002, p. 4) and can be checked using various graphical techniques. Ideally, errors should be random, independent, and normally distributed (Navidi, 2006). An examination of the NELS: 88 and ELS: 2002 variables used within this study indicated the criteria assumptions were appropriate and therefore a multiple regression analysis was appropriate.

Once it is determined that the criteria assumptions are appropriate for the data, a stepwise regression analysis occurs in order to narrow the amount of independent variables that will be included in a final regression prediction equation. Using p-values to determine significant independent variables, a stepwise regression is a form of model selection that "terminates when no variables meet the criteria for being added to or dropped from the model" (Navidi, 2006, p. 594). A coefficient of determination, R^2, will be determined for each possible model in order to determine the goodness-of-fit of the linear model created for the variables included (Navidi, 2006).

Once significant variables were narrowed using a multiple regression analysis, a multiple logistic regression analysis was conducted. A multiple logistic regression, like a multiple linear regression, tested the relationship between independent variables and a dependent variable but unlike a linear regression, a multiple logistic regression allowed for non-linear relationships between the variables (Kutner, Nachtsheim, Neter, & Li, 2005). This allowed the model that best fit the data to be a curve rather than just a line. In addition, a multiple logistic regression model "is also widely used when the response [dependent] variable is qualitative" (Kutner et al., 2005, p. 513) and "allows the probability prediction of a dichotomous outcome that indicates a category rather than a numerical result for the dependent variable" (Wisdom, 2008, p. 62). This method is applicable in this study where the dependent variable was the dichotomous qualitative outcome of a student being a mathematics major at the post-secondary level of education or a major in some area other than mathematics. Unlike the previous analysis methods, a multiple logistic regression does not require the usual criteria. Hence, a logistic regression does not assume that independent variables are normally distributed or linearly related (Kutner et al., 2005) and therefore diagnostic residual plots are analyzed in order to provide information about the adequacy of using a logistic regression model. An examination of the plots indicated a multiple logistic regression analysis was appropriate.

Using a similar stepwise model selection process as used previously in the multiple regression analysis portion of this study, it was determined which variables were and were not significant to a student's decision to major in mathematics at the post-secondary level and created a prediction equation.

Using data sets collected by the United States Department of Education on nationally representative samples provided the ability to generalize to a wider population than generally available. The students used with the samples for these two data sets came from stratified, purposive samples and students chosen came from various regions of the country, from various school sectors, and with various backgrounds. Therefore, generalizations of the results from this study are appropriate to students similar in these various variables of the sample students.

Summary

In summary, this study investigated the relationship between school sector and a student's decision to major in mathematics at the post-secondary level as well as identified potential predictors of mathematics majors. NELS: 88 and ELS: 2002 provided the data necessary for the analysis, which made use of Fisher's exact tests, a multiple regression, and a logistic regression. The analysis methods discussed in this chapter provided the descriptive and inferential statistics presented in the next chapter.

Chapter Four-Results

The relationship between students' high school sector, gender, and ethnicity and their subsequent decision to major in mathematics at the post-secondary level of education was investigated in this study. The purpose was to identify predictors that correlate to a student's choice of majoring in mathematics to provide readers with information regarding how variables within a student's background can affect the decision to major in the area of mathematics.

Tables 1 and 2 list the independent variables included within the study. The dependent variable throughout the study was students' majors at the post-secondary level, in particular, the decision to major in the area of mathematics. Using data from the NELS: 88 as well as data from the ELS: 2002, analysis established the correlation between the variables of interest and a student's decision to major in mathematics.

Participants

Conducted by the United States Department of Education, the studies followed participants from varied geographic locations and of varied backgrounds. Of those participants in NELS: 88 who responded to the demographic questions, ethnic representation was 6.78% Asian, 12.81% Hispanic, 9.23% Black, 70.14% White, and 1.04% American Indian. Table 3 summarizes the population frequencies for each ethnicity according to the dependent variable. Students were classified as having majored in the area of mathematics if they reported earning, as one of their first three degrees, an associate's, bachelor's, or master's degree in the area of mathematics or statistics. Gender representation for the participants in NELS: 88 who responded was 46.99% Male and 53.01% Female. Table 4 summarizes the population frequencies for each gender according to the dependent variable.

Table 3

Frequencies for Dependent Variable by Ethnicities from NELS: 88

	Asian	Hispanic	Black	White	American Indian
Math Major	8	3	1	51	0
Other Major	756	1441	1040	7857	117

Note. From NELS: 88

Table 4

Frequencies for Dependent Variable by Gender from NELS: 88

	Male	Female
Math Major	38	25
Other Major	5311	6010

Note. From NELS: 88

Similarly, of those participants in ELS: 2002 who responded to the demographic questions, ethnic representation was 0.85% American Indian, 9.58% Asian, 13.25% Black, 14.54% Hispanic, 4.82% Biracial, and 56.95% White. Table 5 illustrates the population frequencies for each ethnicity according to the dependent variable. Students were classified as mathematics majors if they reported being enrolled in either a two-year college or a four-year college or university and reported mathematics and statistics as their post-secondary major in 2006 during the second follow-up study. Gender representation for the participants in ELS: 2002 who responded was 49.79% Male and 50.21% Female. Table 6 illustrates the population frequencies for each gender according to the dependent variable.

Table 5

Frequencies for Dependent Variable by Ethnicities from ELS: 2002

	Asian	Black	Hispanic	Biracial	White	American Indian
Math Major	9	4	3	3	37	0
Other Major	1451	2016	2214	732	8645	130

Note. From ELS: 2002

Table 6

Frequencies for Dependent Variable by Gender from ELS: 2002

	Male	Female
Math Major	29	27
Other Major	7624	7690

Note. From ELS: 2002

Treatment of the Data

Frequency tables were constructed using both data sets to disaggregate the data according to variables of interest and Fisher's exact tests were used in the analysis of these frequency tables to determine if there was statistical significance between the variables analyzed. The application of a stepwise multiple regression analysis to each data set determined which independent variables had significant correlations with the dependent variable. Once the highly correlated independent variables were determined, a logistic regression further analyzed the data sets. The resulting equations allowed for the investigation of potential predictive usage of the data sets.

Results and Analysis of Data

Frequency analysis.

The frequency analysis addressed the following questions:

1. Are there significant differences between the proportions of students pursuing the area of mathematics when compared by the type of high school they attended, namely public, Catholic, or other independent private?
2. Are there significant differences between the proportions of students pursuing the area of mathematics when compared by type of high school they attended and when further separated according to gender and ethnicity?

Of those participants in NELS: 88 who responded, students' high school sectors were classified according to their reported school sector in both the 10th grade and 12th grade. Therefore, if a student reported enrollment in a public school in both follow-up studies, then the student was labeled as a public school student. Similarly, if a student reported enrollment in a Catholic high school in both follow-up studies, then the student was labeled as a Catholic school student. If a student reported enrollment in a different religious affiliated private high school or a private non-religious high school in both follow-up studies, then the student was labeled as a private school student. However, if the reported 10th- and 12th-grade school sectors differed, the student's classification changed to a sector transfer. There were two such students within the NELS: 88 data, which the researcher removed from the school sector analysis portion for classification purposes. Table 7 illustrates the frequencies for each school sector according to the dependent variable.

Table 7

Frequencies for Dependent Variable by School Sector from NELS: 88

	Public	Catholic	Private
Math Major	48	6	7
% of Sector	0.49	0.88	1.06

Note. From NELS: 88

This began the analysis that addressed the first proposed hypothesis that there would be significant differences between the proportions of students pursuing the area of mathematics when compared by the type of high school they attended, namely public, Catholic, or other independent private. A Fisher's exact test analysis of the percentage differences between the high school sectors indicated a p-value of 0.0497 indicating statistical significance and supporting the researcher's proposed hypothesis. Further significance test analysis of the sectors is provided in Table 8. Further separation and testing revealed no significant differences between any two high school sectors with regard to the proportion of students who major in mathematics at the post-secondary level. This lack of statistical significance could be an effect of the small overall number of mathematics majors.

Table 8

Statistical Significance (p-values) between High School Sectors from NELS: 88

	Public	Catholic	Private
Public	---------	0.1627	0.0835
Catholic	0.1627	---------	0.7863
Private	0.0835	0.7863	----------

Note. From NELS: 88

The combination of Catholic and private high school data into one group revealed a statistical difference between the proportion of public high school graduates and the proportion of non-public high school graduates that chose to major in mathematics. With 0.97% of non-public high school students majoring in mathematics and 0.49% of public high school students majoring in mathematics, a resulting p-value 0.0446 indicates a significant difference at the 0.05 level.

Further analysis, conducted by disaggregating the NELS: 88 mathematics majors according to student gender addressed a portion of the second proposed hypothesis, which stated that there would be significant differences between the proportions of students pursuing the area of mathematics when compared by the type of high school they attended and when further separated according to gender. This analysis indicated various significant differences. Overall, 0.71% of male student participants became mathematics majors and 0.41% of female student participants became mathematics majors during the NELS: 88. This difference in proportions resulted in a p-value of 0.0421, indicating a statistically significant difference between the various genders and the respective students' probabilities majoring in mathematics at the post-secondary level of education. Separating the mathematics majors according to their school sector, further analysis indicated varied results. Due to the small amount of mathematics majors, the researcher grouped students who attended Catholic or independent private high schools both under the term 'non-public'. This combination provided a large enough data count in both the public and non-public sectors in order to support the statistical significance tests incorporated in this analysis. If the Catholic and independent private high school sectors were left separate, there would not have been enough statistical power to detect a significant difference. Table 9 illustrates the frequencies and percentages for each high school sector separated according to student gender.

Table 9

Frequencies for Dependent Variable by School Sector and Gender from NELS: 88

	Male		Female	
	Public	Non-Public	Public	Non-Public
Math Major	25	11	23	2
Percentage	0.57	1.68	0.46	0.30

Note. From NELS: 88

The results in Table 9 indicate that while 1.68% of males in non-public high schools major in mathematics, only 0.30% of females in non-public high schools major in mathematics. This difference in percentages was statistically significant with a p-value of 0.0121, far below the 0.05 level of significance. However, the different percentage of male and female public school students did not prove significant. Analyzing across sector divisions for each gender also proved to have varied results. The results for the Fisher's exact test indicated a p-value of 0.0045 and therefore a statistically significant difference between the percentage of males from public and non-public high schools who go on to major in mathematics at the post-secondary level supported the proposed hypothesis. There was no significant difference found between the percentage of public and non-public high school females who became mathematics majors, which did not support the hypothesis.

Further analysis conducted by disaggregating the NELS: 88 mathematics majors according to their ethnicity indicated various significant differences. This analysis also addressed a portion of the second proposed hypothesis, which stated that there would be significant differences between the proportions of students pursuing the area of mathematics when compared by the type of high school they attended and when further separated according to both gender and ethnicity. Overall, 1.05% of Asian student participants became mathematics majors, 0.21% of Hispanic students became mathematics majors, 0.10% of Black students majored in mathematics, and 0.64% of White student participants became mathematics majors during the NELS: 88 while 0.00% of the American Indian student participants became mathematics majors at the post-secondary level of education. This difference in proportions resulted in a p-value of 0.0125, indicating a statistically significant difference between the various ethnicities and the respective students' probabilities of majoring in mathematics at the post-secondary level of education. Separating the mathematics majors according to their gender and ethnicity, further analysis indicated varied results. Due to the small amount of Hispanic and Black mathematics majors, the researcher grouped students of these two ethnic groups under the term 'Hispanic/Black' in an attempt to have a large enough count in the ethnic divisions to support the statistical significance tests incorporated in this analysis. No American Indian students majored in mathematics during the NELS: 88 and therefore this ethnicity group did not appear in the analysis. Table 10 displays the frequencies and percentages for each gender separated according to student ethnicity.

Table 10

Frequencies for Dependent Variable by Ethnicity and Gender from NELS: 88

	Asian		Hispanic/Black		White	
	Male	Female	Male	Female	Male	Female
Math Major	4	4	3	1	31	20
Percentage	1.08	1.01	0.27	0.07	0.82	0.48

Note. From NELS: 88

The results in Table 10 indicate that while 1.08% of Asian males majored in mathematics, only 0.27% Hispanic/Black males and 0.82% of White males majored in mathematics. These differences in percentages were not statistically significant with a p-value of 0.0689, above the 0.05 level of significance. On the other hand, 1.01% of Asian females majored in mathematics while Hispanic/Black and White female students only majored in mathematics at 0.07% and 0.48% respectively. These percentages proved to be statistically different with a p-value of 0.0125, indicating significant differences between the females of various ethnicities and the respective students' probabilities of majoring in mathematics at the post-secondary level of education. Table 11 illustrates results of the mathematics majors when further separated by their respective high school sectors. With 25 male and 23 female students of various ethnicities from the public high school sector majoring in mathematics at the post-secondary level, this nearly even split resulted in no statistical difference on the Fisher's exact test when separated by ethnicity and gender. However, when the 11 male and two female students from the non-public high school sectors where analyzed many of the ethnicity and gender combinations resulted in either zeros or very low counts. Since zeros were involved, a Fisher's exact test was not appropriate. The results of this section led to inconclusive results in relation to this portion of the second proposed hypothesis.

Table 11

Frequencies for Dependent Variable by School Sector, Ethnicity, and Gender from NELS: 88

	Public					
	Asian		Hispanic/Black		White	
	Male	Female	Male	Female	Male	Female
Math Major	4	4	2	1	19	18
	Non-Public					
	Asian		Hispanic/Black		White	
	Male	Female	Male	Female	Male	Female
Math Major	0	0	1	0	10	2

Note. From NELS: 88

Of those participants in ELS: 2002 who responded, students were classified by their high school sectors according to their reported school sector in both the base-year and first follow-up study. The variable F1CTLPTN was used in the classification of students to specific high school sectors. If a student reported enrollment in a public school during the base-year study and during the first follow-up study, then the student was labeled as a public school student. There were no distinctions made by the researcher between public school students who stayed within the same school, those who transferred to a different public school, and those who graduated early from a public school. Similarly, if a student reported enrollment in a private high school during the base-year study and during the first follow-up study, then the student was labeled as a private school student. Once again, there were no distinctions made by the researcher between private school students who stayed within the same school, those who transferred to a different private school, and those who graduated early from a private school. However, if the reported school sectors of the base-year study and first follow-up study differed, the student was classified as a sector transfer but there were no such students, within the ELS: 2002 data set, who then went on to major in mathematics. In addition, there were no students who reported dropping out of either sector between the base-year and the first follow-up study who then majored in mathematics. Using the data as it was recorded, Catholic and other private high schools were combined into one group within the data set and therefore it cannot be determined whether students went to Catholic high school during both the base-year and first follow-up study or whether students attended a different private sector high school during these first two reporting periods. Hence, the analysis on the ELS: 2002 data set was presented in terms of public school students and non-public school students. Table 12 illustrates the frequencies for each school sector according to the dependent variable.

Table 12

Frequencies for Dependent Variable by School Sector from ELS: 2002

	Public	Non-Public
Math Major	41	15
% of Sector	0.34	0.48

Note. From ELS: 2002

This began the analysis that addressed the first proposed hypothesis that there would be significant differences between the proportions of students pursuing the area of mathematics when compared by the type of high school they attended, namely public or non-public. A Fisher's exact test analysis of the percentage differences between the high school sectors indicated a p-value of 0.0755 indicating no statistical significance between the public and private sectors. This lack of statistical significance could be an effect of the small overall number of mathematics majors and does not support the proposed hypothesis.

Further analysis, conducted by disaggregating the ELS: 2002 mathematics majors according to student gender addressed a portion of the second proposed hypothesis, which stated that there would be significant differences between the proportions of students pursuing the area of mathematics when compared by the type of high school they attended and when further separated according to gender. This analysis indicated various significant differences. Overall, 0.38% of male student participants became mathematics majors and 0.35% of female student participants became mathematics majors during the ELS: 2002. This difference in proportions resulted in a p-value of 0.7902, indicating no statistically significant difference between the various genders and the respective students' probabilities of majoring in mathematics at the post-secondary level of education. Further analysis was conducted separating the mathematics majors according to their high school sector. Table 13 illustrates the frequencies and percentages for each high school sector separated according to student gender.

Table 13

Frequencies for Dependent Variable by School Sector and Gender from ELS: 2002

	Male		Female	
	Public	Non-Public	Public	Non-Public
Math Major	24	5	17	10
Percentage	0.43	0.33	0.30	0.68

Note. From ELS: 2002

The results in Table 13 indicate that while 0.68% of females in non-public high schools major in mathematics, only 0.33% of males in non-public high schools major in mathematics. Although this difference in percentages, with a p-value of 0.2036, was not statistically significant, the percentage of females increased from the NELS: 88 results presented in Table 9 while the percentage of males greatly decreased. With closer percentages among the genders within the public school sector, the difference also proved to be insignificant. Analyzing across sector divisions for each gender also proved to have varied results. The results for the Fisher's exact test indicated a p-value of 0.0507 and therefore this borderline result can be considered a statistically significant difference between the percentage of females from public and non-public high schools who go on to major in mathematics at the post-secondary level. This result supports the researcher's proposed hypothesis. There was no significant difference found between the percentage of public and non-public high school males who became mathematics majors and therefore there was not enough evidence to support the proposed hypothesis. These findings are opposite of the findings from the NELS: 88.

Further analysis conducted by disaggregating the ELS: 2002 mathematics majors according to their ethnicity indicated various significant differences. It addressed a portion of the second proposed hypothesis, which stated that there would be significant differences between the proportions of students pursuing the area of mathematics when compared by the type of high school they attended and when further separated according to both gender and ethnicity. Overall, 0.62% of Asian student participants became mathematics majors, 0.14% of Hispanic students became mathematics majors, 0.20% of Black students majored in mathematics, 0.41% of Biracial students majored in mathematics, and 0.43% of White student participants became mathematics majors during the ELS: 2002. Results indicated 0.00% of the American Indian student participants became mathematics majors at the post-secondary level of education and therefore will not appear in the analysis in this report. This difference in proportions resulted in a p-value of 0.0685, indicating that there was no statistically significant difference between the various ethnicities and the respective students' probabilities of majoring in mathematics at the post-secondary level of education. Separating the mathematics majors according to their gender and ethnicity, further analysis indicated varied results. Table 14 displays the frequencies and percentages for each gender separated according to student ethnicity.

Table 14

Frequencies for Dependent Variable by Ethnicity and Gender from ELS: 2002

	Asian		Black		Hispanic		Biracial		White	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Math Major	4	5	1	3	1	2	2	1	21	16
Percentage	0.54	0.69	0.10	0.30	0.09	0.18	0.54	0.27	0.49	0.36

Note. From ELS: 2002

The results in Table 14 indicate that while 0.54% of Asian males and Biracial males majored in mathematics, only 0.10% of Black males, 0.09% of Hispanic males, and 0.49% of White males majored in mathematics. These differences in percentages were not statistically significant with a p-value of 0.1095, above the 0.05 level of significance. On the other hand, 0.69% of Asian females majored in mathematics while Black, Hispanic, Biracial and White female students only majored in mathematics at 0.30%, 0.18%, 0.27%, and 0.36% respectively. These percentages proved to be insignificant in differences with a p-value of 0.5115, indicating no significant differences between the females of various ethnicities and the respective students' probabilities of majoring in mathematics at the post-secondary level of education. Table 15 provides the results of further separation of the mathematics majors according to their respective high school sectors. With 24 male and 17 female students of various ethnicities from the public high school sector majoring in mathematics at the post-secondary level, this split resulted in no statistical difference on the Fisher's exact test when separated by ethnicity and gender. However, when the five male and 10 female students from the non-public high school sectors where analyzed many of the ethnicity and gender combinations resulted in either zeros or very low counts. Since zeros were involved, a Fisher's exact test was not appropriate. The results of this section led to inconclusive results in relation to this portion of the second proposed hypothesis.

Table 15

Frequencies for Dependent Variable by School Sector, Ethnicity, and Gender from ELS: 2002

	Public									
	Asian		Hispanic		Black		Biracial		White	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Math Major	4	3	1	3	1	2	2	1	16	8
	Non-Public									
	Asian		Hispanic		Black		Biracial		White	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Math Major	0	2	0	0	0	0	0	0	5	8

Note. From ELS: 2002

Comparing the total number of mathematics majors from the two data sets, a z-test for proportions indicated a statistically significant difference from the NELS: 88 data set collection period to the ELS: 2002 data set collection period. With a p-value of 0.0129, the comparison of 63 mathematics majors in the older data set to 56 mathematics majors in the newer data set indicates a significant decrease in the number of students pursuing the area of mathematics.

Multiple Regression analysis.

The multiple regression analysis addressed the following question:

1. Are there predictors of mathematics majors in post-secondary education?

Using the NELS: 88 data set, simple generalized linear mixed models were run for each of the independent variables in correlation with the dependent variable in order to determine which independent variables from the original list in Table 1 proved to have a significant effect on the dependent variable. Table 16 lists the independent variables analysis examined and their respective p-values, which were determined by running a generalized linear mixed model for each independent variable in correlation to the dependent variable. This began the analysis that addressed the third hypothesis that there would be several significant predictors of mathematics majors in post-secondary education.

With the exception of a few variables, the independent variables that had a p-value less than 0.05 were deemed significant and were used in the multiple regression analysis. Some variables such as BYS7OCC (Father/Male Guardian's Occupation) and BYS45 (How Far in School the Student Thinks He or She Will Get) had significant p-values. This indicated a correlation to the dependent variable, but further examination determined that there were not enough mathematics majors to determine which areas included under those particular independent variables truly correlated with the dependent variable. Using the significant independent variables, the researcher ran a backwards selection technique to narrow the independent variables further. This variable selection process included all the significant variables into one model, which attempted to predict the dependent variable with as much accuracy as possible, and reduced the model one independent variable at a time depending upon each individual variable's p-value. The backwards multiple regression variable selection process determined that a single variable, F2RHMA_C (Student's Units in Mathematics as of Second Follow-Up), was significant and therefore has the strongest effect on a student's decision to major in mathematics. This significant variable detailed how many units in mathematics each student had as of the second follow-up study. This result supports the third hypothesis of the study.

Table 16

Significance of Independent Variables from NELS: 88

Object Code	p-value
SEX	0.0083
RACE	0.0357
BYFCOMP	0.2940
BYS34B	0.0012
BYS34A	0.0001
BYS4OCC	0.1406
BYS7OCC	0.0099
BYFAMINC	0.8902
BYSESQ	<0.0001
BYS45	0.0018
BYS52	0.0081
BY2XMSTD	<0.0001
BY2XMQ	<0.0001
BY2XMPP1	0.0522
BY2XMPP2	0.0029
BY2XMPP3	0.0016
BY2XMPP4	0.0248
BY2XMPP5	0.2189
G8CTRL	0.0085
G8URBAN	0.4414
G8REGON	0.0425
BYRATIO	0.1541
F1S49	0.0030
F1S53B	0.5394
F12XMSTD	<0.0001
F12XMQ	<0.0001
F12XMPP1	0.4384
F12XMPP2	0.8910
F12XMPP3	0.8743
F12XMPP4	0.8289
F12XMPP5	0.3309
G10CTRL1	0.0449
F1S18B	0.0002
F2S43	0.0010
F2S62	<0.0001
F2S64B	0.0250
F22XMSTD	0.0275
F22XMQ	<0.0001
F22XMPP1	0.1139
F22XMPP2	0.2089
F22XMPP3	0.3174
F22XMPP4	0.4273
F22XMPP5	0.1822
G12CTRL1	0.1063
F2RHMA_C	0.0062
F3PSEATN	<0.0001
PSELASTY	<0.0001
PSELASMJ	<0.0001
F4EDGR1	<0.0001
F4ESCT1	0.1525
F4HHDG	0.2823

Note. From NELS: 88

Simple generalized linear mixed models were run for each of the independent variables in correlation with the dependent variable using the ELS: 2002 data set in order to determine which independent variables from the original list in Table 2 proved to have a significant effect on the dependent variable. Table 17 lists the independent variables examined and their respective p-values, which were determined by running a generalized linear mixed model for each independent variable in correlation to the dependent variable. This began the analysis that addressed the third hypothesis that there would be several significant predictors of mathematics majors in post-secondary education.

With the exception of a few variables, the independent variables that had a p-value less than 0.05 were deemed significant and were used in the multiple regression analysis. Some variables such as F1OCC30 (Student's Predicted Occupation at Age 30) and F2PS1SEC (Student's Sector of First Post-secondary Institution) had significant p-values, which indicated a correlation to the dependent variable, but further examination determined that there were not enough mathematics majors to determine which areas included under those particular independent variables truly correlated with the dependent variable. Using the significant independent variables, a backwards selection technique was run to narrow the independent variables further. This variable selection process included all the significant variables into one model, which attempted to predict the dependent variable with as much accuracy as possible, and reduced the model one independent variable at a time depending upon each individual variable's p-value. The backwards multiple regression variable selection process determined that two independent variables, F1TXMSTD (Student's Math Test Standardized Score as Reported in First Follow-Up) and F1RMAT_P (Student's Units in Mathematics on High School Transcript), were significant and therefore have the strongest effects on a student's decision to major in mathematics. These significant variables respectively reported the student's standardized math test score during the first follow-up study and how many units in mathematics each student had on his or her high school transcript. These results support the third hypothesis of the study.

Table 17

Significance of Independent Variables from ELS: 2002

Object Code	p-value
BYSEX	0.7650
BYRACE	0.2942
BYFCOMP	0.6240
BYGNSTAT	0.3304
BYMOTHED	0.0023
BYFATHED	0.0002
BYOCCUM	0.1080
BYOCCUF	0.2560
BYINCOME	0.0267
BYSES1QU	0.0002
BYSTEXP	<0.0001
BYOCC30	0.9970
BYTXMSTD	<0.0001
BYTXMQU	<0.0001
BYTX1MPP	0.0004
BYTX2MPP	0.0123
BYTX3MPP	<0.0001
BYTX4MPP	<0.0001
BYTX5MPP	<0.0001
BYMHDEG	0.3415
BYSCRTL	0.0961
BYURBAN	0.9488
BYREGION	0.5534
BYREGURB	0.7537
BYREGCTL	0.5837
F1STEXP	<0.0001
F1BYDEX	0.9903
F1OCC30	<0.0001
F1TXMSTD	<0.0001
F1TXMQU	<0.0001
F1TX1MPP	0.0379
F1TX2MPP	0.0650
F1TX3MPP	0.0002
F1TX4MPP	<0.0001
F1TX5MPP	<0.0001
F1HIMATH	0.9333
F1CTLPTN	0.1700
F1PSEPLN	<0.0001
F2EDLEVL	<0.0001
F2PS1SEC	0.0060
F1RMAT_P	<0.0001
F1RGPP2	<0.0001
F2B15	<0.0001
F2B22	0.0115

Note. From ELS: 2002

Therefore, the multiple regression analysis of both data sets resulted in just one significant variable for the NELS: 88 data set and two significant variables for the ELS: 2002 data set which is the result of multicollinearity within the data sets. Multicollinearity is a result of two or more independent variables that are strongly correlated and a “multiple regression may not be able to determine which is the important one" (Navidi, 2006, p. 577). As a result, especially in small samples, independent variables may appear insignificant while the overall model generated may be statistically significant. Multicollinearity was detected within the NELS: 88 and ELS: 2002 data sets by examining the strong correlations between various independent variables. Table 18 and Table 19 present variables that are highly correlated to one another within the NELS: 88 and ELS: 2002 data sets, respectively. The variables were deemed highly correlated if the two variables had a Pearson Correlation Coefficient with an absolute value of 0.90 or greater. The Pearson Correlation Coefficient "measures the strength and direction of a linear relationship between two variables" (Bluman, 2009, p. 533) and can take on any value between a negative one and a positive one (Bluman, 2009).

Table 18

Correlation of Independent Variables from NELS: 88

Variable One	Variable Two	Pearson Correlation Coefficient
BY2XMQ	BY2XMSTD	0.93472
BY2XMQ	BY2XMPP2	0.90931
BY2XMPP2	BY2XMPP3	0.98861
F12XMSTD	F12XMQ	0.96068
F22XMSTD	F22XMQ	0.96113

Note. From NELS: 88

Table 19

Correlation of Independent Variables from ELS: 2002

Variable One	Variable Two	Pearson Correlation Coefficient
BYTXMSTD	BYTXMQU	0.93240
BYTXMQU	BYTX3MPP	0.91227
F1TXMQU	F1TXMSTD	0.94144
F1TXMQU	F1TX4MPP	0.90374

Note. From ELS: 2002

Within both data sets, variables that depicted students' mathematics standardized test scores were highly correlated with the student's mathematics quartile. A student's mathematics quartile was also highly correlated with the student's probability of being proficient in various levels of mathematics content. Therefore, when such variables are included together within a regression analysis, both may appear to be insignificant variables because they are highly correlated and decrease the other variable's statistical power.

Logistic Regression analysis.

The logistic regression analysis continued to address the following question:

1. Are there predictors of mathematics majors in post-secondary education?

The independent variables deemed most significant according to the previous multiple regression analysis would, typically, then be used in the creation of a prediction equation using a logistic regression. However, with so few mathematics majors within the NELS: 88 and ELS: 2002 data sets it would be difficult to create a meaningful generalized prediction equation. Therefore, the discussion of the analysis of meaningful predictors is in terms of the odds ratios for significant variables found within the multiple regression analysis portion of this study. This continues the analysis that addressed the third hypothesis that there would be several significant predictors of mathematics majors in post-secondary education.

Analyzing the significant variables from the NELS: 88 data set, it was found that while there was not a significant difference in the odds of White students majoring in mathematics when compared to Asian students majoring in mathematics, there was a significant difference between Asian and Hispanic or Black students. Asian students were 6.579 times more likely to become mathematics majors than Hispanic or Black students. In the comparison of genders, males were 1.720 times more likely to become mathematics majors than females. Analysis examining parent's highest level of education found that for every unit increase, the student was 1.450 times more likely to major in mathematics. This indicates that students with highly educated parents were more likely to pursue mathematics than students whose parents had less education. Similarly, for every socioeconomic quartile increase, the student was 2.209 times more likely to major in mathematics. This result suggests that students from higher socioeconomic backgrounds are more apt to pursue mathematics than students who come from lower socioeconomic households.

Students who believed they would obtain higher levels of education during their eighth-grade year were 2.120 times more likely to major in mathematics than students who predicted they would not continue on to further degrees after high school. For every quartile increase on the eighth-grade mathematics proficiency test, a student was 3.809 times more likely to major in mathematics. Hence, students who tested more proficient in mathematics were more likely to pursue it than students in the lowest quartile who were not as proficient in the subject. Likewise, students who predicted they would continue their education in the 10th grade were 1.740 times more likely to pursue mathematics than those students who did not plan on continuing in school and with every quartile increase on the 10th-grade mathematics proficiency test, students were 5.293 times more apt to pursue mathematics. The likelihood increased for students scoring high on their 12th-grade mathematics proficiency test. For every quartile increase on the 12th-grade mathematics proficiency test, students were 6.865 times more likely to become a mathematics major.

Analyzing the NELS: 88 data set further, it was found that while there was not a significant difference in the odds of public sector students majoring in mathematics when compared to Catholic school students majoring in mathematics, there was a significant difference between public and independent-private school students. Students attending independent-private schools in their eighth-grade year were 3.348 times more likely to pursue mathematics than public school students at the same grade level. Similar differences existed at the 10th-grade year but none of the two-sector comparisons had significant differences. Also, students with additional units of mathematics on their high school records were more likely to pursue mathematics than students with less mathematics units.

Analyzing the significant variables from the ELS: 2002 data set, it was found that for every unit increase in the mother's highest level of education, the student was 1.222 times more likely to major in mathematics whereas for every unit increase in the father's highest level of education, the student was 1.261 times more likely to pursue mathematics. This, once again, indicates that students with highly educated parents were more likely to pursue mathematics than students whose parents had less education. Similarly, as total family income increased, the student was 1.149 times more likely to major in mathematics. In addition, for every socioeconomic quartile increase, the student was 1.658 times more apt to pursue mathematics. These results suggest that students from higher socioeconomic backgrounds are more apt to pursue mathematics than students who come from lower socioeconomic households.

Students who believed they would obtain higher levels of education during their 10th-grade year were 1.783 times more likely to major in mathematics than students who predicted they would not continue on to further degrees after high school. For every quartile increase on the 10th-grade mathematics proficiency test, a student was 4.367 times more likely to major in mathematics. Hence, students who tested more proficient in mathematics were more likely to pursue it than students in the lowest quartile who were not as proficient in the subject. Likewise, students who predicted they would continue their education in the 12th grade were 1.898 times more likely to pursue mathematics than those students who did not plan on continuing in school and with every quartile increase on the 12th-grade mathematics proficiency test, students were 4.132 times more apt to pursue mathematics.

Analyzing the ELS: 2002 data set further, results revealed a significant difference in the odds of students majoring in mathematics when compared by their post-secondary plans for after high school. For every additional post-secondary level students planned to attend, the likelihood of them pursuing mathematics was 2.933 times more likely. Also, students with additional units of mathematics on their high school records were more likely to pursue mathematics than students with less mathematics units. For every additional unit of mathematics a student had on his or her high school transcript, he or she was 2.457 times more likely to major in mathematics. Similarly, when examining students' grade point averages for all the courses they had taken throughout high school, for every half point above a 1.00 grade point average, a student was 3.185 times more likely to major in mathematics. As of the second follow-up study, students who reported attempting higher levels of education were 5.848 times more likely to major in mathematics. Hence, students who had attempted or enrolled in a four-year institution were 5.848 times more apt to major in mathematics when compared to those students enrolled in a two-year college.

Summary

Analysis of data from NELS: 88 and ELS: 2002 resulted in findings that supported some of the proposed hypotheses and rejected others. Some findings were judged to be inconclusive. While there were significant differences between the high school sectors according to the NELS: 88 data set, there were no differences found between the public and private sectors in the ELS: 2002 data set. Similarly, according to the NELS: 88 data set, significant differences existed between males who attended public and private high school sectors while no significant differences existed between females of the various school sectors. However, within the ELS: 2002 data set the opposite results occurred, indicating significant differences in public and private sector females majoring in mathematics but no differences between the various sector males. Due to a small number of mathematics majors within both data sets, when data was disaggregated by school sector, gender, and ethnicity, results proved to be inconclusive.

The multiple regression analysis as well as the logistic regression analysis revealed several significant predictors of mathematics majors at the two time points analyzed through the NELS: 88 and ELS: 2002 collection periods. This study established the odds between various independent variables included within the data sets and a student's likelihood of pursuing mathematics.

Chapter five discusses the results of this study as well as recommends possible applications of these results. Recommendations for future studies in this area are also discussed.

Chapter Five- Discussion

This study analyzed the relationship between students' high school sector, gender, and ethnicity and their subsequent decision to major in mathematics at the post-secondary level of education. The purpose was to identify predictors that correlate to a student's choice of majoring in mathematics to provide information regarding how variables within a student's background can affect the decision to major in the area of mathematics.

Understanding who mathematics majors are, including the types of high school they attended and their ethnicities, may provide some insight into which students are becoming interested in these areas during their high school experience and which groups educators need to focus more attention on in order to increase their participation in the area of mathematics. The use of the results of this study can help in the development of secondary and post-secondary programs that increase student interest in mathematics in groups underrepresented in the field of mathematics.

This study found that among minority students, Asian students are more likely to pursue mathematics than are Hispanic or Black students. In addition, there is a positive relationship between a parent's education level and a student's likelihood of pursuing mathematics, which indicates that, students whose parents are highly educated are more apt themselves to pursue mathematics than students whose parents are less educated. The results indicate that there are also positive relationships between students' likelihood of majoring in mathematics and their desire to attend post-secondary education, the units of mathematics they completed in high school, and their socioeconomic background.

Differences in the proportions of students majoring in mathematics from the various high school sectors also became apparent. While there was a significant difference between the high school sectors according to the NELS: 88 data set, there was no difference found between the public and private sectors in the ELS: 2002 data set. However, according to the NELS: 88 data set, significant differences existed between males who attended public and private high school sectors while no significant differences existed between females of the various school sectors. Within the ELS: 2002 data set the opposite results occurred, indicating a significant difference in public and private sector females majoring in mathematics but no difference between the various sector males.

Interpretation

Examining the results of this study, the numbers indicate that there has been a significant decrease in the number of students who pursue mathematics at the post-secondary level of education from the time of the collection of the NELS: 88 data to the collection of the ELS: 2002 data. Despite some researchers who have argued that the mathematics crisis is a fictitious issue, the decline in the number of mathematics majors from the NELS: 88 to the ELS: 2002 proves otherwise. The numbers also indicate that while the number of mathematics majors may be declining, the number of girls pursuing mathematics, although not statistically significant, is slightly increasing especially among students attending private schools. However, overall, the high school sectors are no longer significantly different in terms of the number of mathematics majors that come from each. Additionally, ethnic minorities continue their underrepresentation in the area of mathematics.

Implications and Recommendations

Taking into consideration the results and interpretations of this study, it is recommended that educators at all levels of education continue to stress the important role that mathematics plays in various career paths. Results showed that students with more credits in mathematics on their high school transcripts are more likely to pursue mathematics. Therefore, if educators are to end the mathematics crisis in the United States, they must encourage and require students to take a mathematics or statistics course each year throughout their high school careers. Once students are in class, mathematics teachers must find methods of instruction that meet the academic needs of students as well as help students become interested in the field. Such methods would benefit minorities and women who, as shown in the literature review, have different learning styles and therefore may need the information presented in new and various manners in order to grasp the concepts.

Educational institutions at all levels may benefit from professional development for their instructors on methods and techniques that correlate with an increase in student interest within the field of mathematics.

Future Studies

Results of this study indicated 63 mathematics majors from the 12,144 student participants in the NELS: 88 data set and 56 mathematics majors from the 16,197 student participants in the ELS: 2002 data set. With such limited numbers in terms of mathematics majors, interpretation is limited and some statistical tests proved to be inconclusive when conducted on the small samples. Therefore, one factor that could possibly strengthen this study would be to acquire data from a larger sample of mathematics majors. If the United States Department of Education collects data on students pursuing mathematics at all post-secondary institutions, then the interpretations and tests run in this study would be strengthened by the additional data. In addition, a data set that further separates school sectors according to single gender or coeducational could possibly help in additional findings. A great deal of research within the literature review questioned whether the gender composition of a classroom could affect a student's interest and understanding in a subject. Acquiring a data set that allows one to disaggregate mathematics majors by single gender or coeducational settings could strengthen the debate in one direction or the other.

Results from this study may have been strengthened by comparing instructional methods typical of the private and public high school sectors. Through observations and interviews, perhaps a difference in methods could be established and when presented in combination with the results of this study, reasons for the differences in the numbers could be established. Interviews with a variety of mathematics majors could also strengthen this study by acquiring the personal accounts of why they personally chose to pursue mathematics. The question of whether or not their decision to major in mathematics was due to their school sector, their parents, a teacher, or some other factor may be obtained. The personal stories of some mathematics majors, past and present, could reveal trends in what personally helped them to make the decision to major in mathematics. Future research in this area may provide information into the various reasons behind students' decisions to pursue mathematics.

Summary

The area of mathematics has been at the center of educational debate for many decades. With so few post-secondary students majoring in mathematics today, this study focused on identifying who mathematics majors are including the types of high school they attended, their genders, and their ethnicities in order to provide some insight into which students are becoming interested in the area of mathematics as well as to close a gap in the current literature. The results of this study provide the data many have debated.

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